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China Report

ECONOMIC AFFAIRS

No. 395

ENERGY: STATUS AND DEVELOPMENT -- XXI

SMALL-SCALE HYDROPOWER: VITAL LINK IN RURAL ELECTRIFICATION EFFORT

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CONTENTS

HYDROPOWER

SMALL-SCALE HYDROPOWER OPERATIONS GENERATE 16.3 BILLION KWH IN 1982

Beijing SHUILI FADIAN [WATER POWER] in Chinese No 2, 12 Feb 83 p 53

[Article: "In 1982, Installed Capacity of Small Hydroelectric Power of the Nation Reaches 8 Million Kilowatts: Electricity Output Reached 16.3 Billion Kilowatt-hours"]

[Text] In 1982, each locality maintained the principle of "building, managing, and using its own electric power," and implemented the policy of "using electric power to nurture electric power." Small hydroelectric power realized new progress in readjustment. By the end of 1982, more than 1,400 small hydroelectric power stations were completed and began production throughout the nation. Installed capacity increased by 440,000 kilowatts. The cumulative installed capacity reached 8 million kilowatts. Because management was strengthened and seasonal electric power was utilized, in 1982, small hydroelectric power stations generated 16.3 billion kilowatt-hours of electricity, an increase of 13 percent over 1981. Last year, Guangdong Province added 313 new small hydroelectric power stations, 100,000 kilowatts in additional installed capacity, for a cumulative installed capacity of 1.22 million kilowatts, China's first province to surpass 1 million kilowatts. The four provinces added 60,000 kilowatts in installed capacity, and the cumulative installed capacity reached 850,000 kilowatts. Hunan Province added 40,000 kilowatts, for a cumulative installed capacity of over 800,000 kilowatts. Some provinces (regions) in the border areas also realized progress. Another 39 small-scale hydroelectric power stations in the Xizang Plateau began generating electricity.

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CSO: 4013/158

ACCELERATING SMALL-SCALE HYDROPOWER TO ACHIEVE RURAL ELECTRIFICATION

Beijing SHUILI SHUIDIAN JISHU [WATER RESOURCES AND HYDROPOWER ENGINEERING] in Chinese No 6, 20 Jun 83 pp 1-4

[Article by Li Peng [2621 7720], first vice minister of the Ministry of Water Resources and Electric Power: "Accelerating Development of Small-Scale Hydropower Stations To Realize Rural Electrification in China"]

[Text] I. Accelerating the Development of Small-Scale Hydropower Has Practical Significance for Promoting China's Four Modernizations

In the 30-odd years since the founding of the PRC, there have been great developments in China's rural electricity usage. In the early period the volume of rural electricity usage nationwide was only 20 million kWh a year, so it might be said that basically there was no electricity usage. Today, China's annual electricity usage in rural areas has reached 45 billion kWh, about 14 percent of the generating capacity nationwide. Over half the production brigades now use electricity for irrigation, threshing, winnowing, edible oil processing, commune and brigade industry, and domestic illumination, all of which has played a prominent role in promoting the development of agricultural production and raising the level of the peasants' material and cultural life. However, we should soberly note that nearly half the rural production brigades still have not begun to use electricity. Most of them are concentrated in mountainous, pastoral, and remote areas and in old revolutionary bases, minority nationality regions, and economically backward regions. This is a major problem which will require a long period of determined effort before it is resolved.

Agriculture is the foundation of the national economy and has the most important position in the national economy. Our party has always taken agricultural development seriously. When the 12th Party Congress decided on the strategic goal of striving to quadruple the gross value of annual industrial and agricultural output in the next 20 years, it also decided that agriculture was one of the strategic priorities of economic development. If the agricultural problem is resolved, it can spur on the development of all trades and industries and promote the realization of the strategic mission to quadruple the gross value of industrial and agricultural output. If agriculture is to develop, it must have electricity, whether to promote the rural material and cultural levels or to improve the standard of living of the peasants. For this reason, rural electrification is a very important and

enormous strategic mission before us. The important mission of rural electrification in the next 20 years is to provide electricity to the major portion of rural areas nationwide which are still without electricity and bring about an increase in electricity usage in rural areas which already have electricity and, by the end of this century, to bring electricity usage of most rural areas nationwide close to the current levels of electricity usage of major metropolitan areas and bring about Chinese-style rural electrification which is at the same as our level of comparatively well-off life.

Our country is vast, economic development is very uneven, and electric supply through major power networks now is in short supply, so relying entirely on the nation to take care of electricity and on the major power networks to satisfy the needs of rural electrification is both unrealizable and uneconomical. Leading comrades of the Central Committee have repeatedly said that electricity usage of the 800 million peasants will depend mainly on self-reliance, small-scale hydro and thermal operations and wind power, geothermal, and other energy sources to generate electricity. These directives are entirely correct. Thus, rural electrification will have to rely on policy and various electricity generating energy sources supplementing each other.

Developing small-scale hydropower is the most practical method and has the most economic value of the various forms of developing small-scale power stations. China has an abundance of small-scale hydropower resources, exploitable to about 70 million kilowatts. Over 1,100 of the more than 2,000 counties nationwide have small-scale hydropower resources of over 10,000 kilowatts, and some of over 100,000 kilowatts. Presently, there are over 80,000 small-scale hydropower stations (i.e., power stations with single generator capacity below 6,000 kilowatts and total capacity below 12,000 kilowatts) throughout the nation with a total installed capacity of 8 million kilowatts and an annual generating capacity of 17.2 billion kWh. These have played a very great role in developing agricultural production and improving the material and cultural standard of living of the peasants. According to surveys, because they paid attention to developing hydropower, in many counties local industrial production and the people's standard of living improved very rapidly. For example, in Yongchun County, Fujian Province, they have exploitable hydropower resources of 69,000 kilowatts. They have already built 252 small-scale hydropower stations with a rated capacity of 24,000 kilowatts, and have formed 3 rural electric networks. Ninety-five percent of the production brigades and 90 percent of the rural households in the county have electricity. They plan to build another 10,000 kilowatts of hydropower before 1987. Or again, Cili County in Hunan Province has exploitable hydropower resources of 190,000 kilowatts and has already built 131 small-scale hydropower stations with an installed capacity of 21,000 kilowatts, 1 small-scale thermoelectric power station with an installed capacity of 3,000 kilowatts, and formed a small-scale electric network centered on county seats. Every commune in the county and over half the production brigades and rural households have electricity. They plan to add another 21,000 kilowatts of hydroelectric power before 1987. The experience of Yongchun and Cili Counties in developing small-scale hydropower truly merits our serious consideration. It has demonstrated the advantages of developing small-scale hydropower so there is solid experience which merits conscientious study and promotion. The hydropower which has already been developed nationwide is only

11 percent of the exploitable hydropower resources, so there is still a great deal of potential. Thus, accelerating the development of small-scale hydropower has important practical significance for realizing our rural electrification and promoting our four modernizations.

II. The Directions and Policies and Some Measures Which Must Be Thoroughly Implemented in Accelerating Development of Small-Scale Hydropower

A. The Policy of "Self-Construction, Self-Management, and Self-Use" Must Be Carried Out Conscientiously and Thoroughly

In China, the policy of rural electrification should be realized by walking on two legs--large-scale power networks and power plants should be run by the state and small-scale power networks and power plants should be run by local areas, communes and brigades, and by the masses mobilizing all positive factors to accelerate the development of rural electrification. According to our actual situation, currently, a large portion of rurally used electricity is already within the electricity supply region of a large-scale power network and future growth of electricity usage should also rely on supply by a large-scale power network. For the other portion of districts which are supplied by small-scale rural or local power networks and districts which do not have electricity service, the problem of future electricity usage should be resolved by small-scale hydropower, thermoelectric, and wind power operations on the basis of local conditions depending on the specific situation in terms of energy resources.

Thus, all localities which have small-scale hydropower resources, especially where small-scale hydropower resources are more abundant, should actively develop hydropower relying primarily on small-scale hydropower to carry out rural electrification. To accelerate the development of small-scale hydropower, it is necessary to carry out the policy of "self-construction, self-management, and self-use."

"Self-construction" means that the capital required for rural small-scale hydropower construction should come mainly from funds the local areas raise themselves, pooling of resources by the peasants, and labor service investment, with state use of long-term low interest loans and other methods to provide appropriate subsidies and support. Profits from small-scale hydropower and profits derived from large-scale power network purchase of electricity should not go into local revenues, but should be used entirely for developing rural electric power to carry out the policy of "using electricity to develop electricity."

Small-scale hydrpower not only should be run by counties, but communes and brigades should also be encouraged to operate it and in areas in which the conditions exist the peasants should be encouraged to operate it themselves. After the peasants achieve some prosperity, they should be induced to invest in construction of small-scale hydropower and adopt the method of pooling funds to buy shares, including labor service investment, drawing dividends according to shares; bonuses are generally higher than bank interest and it will also guarantee making good on the commitment mobilizing the initiative of the peasants to take part in operating power stations.

"Self-management" means that after construction of a small-scale hydropower station, ownership rights and management rights belong to the locality and the peasants, the state will not take it over. To facilitate management, communes and county towns which are the focus of a small-scale hydropower station may have their own electricity supply district, form a rural power network, carry out independent accounting, and be responsible for profit and loss. To foster the development of small-scale hydropower, provincial electric power bureaus and power supply bureaus can negotiate the scope of small-scale hydropower supply with local areas and make the necessary adjustments on the basis of the actual situation.

"Self-use" means that the direction of local area, commune and brigade, and peasant operated hydropower stations should be towards the rural areas and the small cities, mainly to serve agricultural production and the lives of the peasants, and should not have as its main aim sale to state power networks for profits. The electric power generated by small-scale hydropower stations should be supplied to the local area and in a balanced way. Of course, if there is still excess electricity it can also be sold to large-scale power networks. For example, Longmen County in Guangdong Province annually sells about 30 million kWh of small-scale hydropower to the Guangdong power network.

B. It Is Necessary To Deal With the Relationship Between Small-Scale Hydropower and Large-Scale Power Networks

In our country there is no contradiction in fundamental economic interests of small-scale hydropower and large-scale power networks, there should be a relationship between them of socialist cooperation in which each supplies what the other needs, balancing surpluses and shortages, providing mutual assistance and support.

For a time in the past, in regions where small-scale hydropower stations were rather concentrated and were in operation in connection with large-scale power networks, there were some contradictions between small-scale hydropower and large-scale power networks in the distribution of economic interests and when this was handled poorly it had an impact on exploiting the potential of small-scale hydropower, influenced the development of small-scale hydropower and, to a certain extent, influenced also the security and economy of large-scale power networks. Thus, handling the relationship between small-scale hydropower and large-scale power networks is a question which urgently needs to be resolved correctly. Recently, on the basis of survey research, the Ministry of Water Resources and Electric Power and the Sichuan Provincial People's Government together formulated the document "Some Stipulations on Actively Developing Small-Scale Hydropower in Sichuan Province," and while attending to the interests of the state, local area, collective, and individual, set forth principles for correct handling of the relationship between small-scale hydropower and large-scale power networks. These principles are: voluntary association of networks, freedom to withdraw from a network, equality and mutual benefit, signed agreements, and joint compliance. This document has already been circulated nationwide and local areas can operate in accordance with it, depending on actual local circumstances.

In correctly handling the relationship of small-scale hydropower and large-scale power networks, it is also necessary to emphasize and correctly handle the following points:

1. In districts where there is a shortage of electricity supplied by large-scale power networks, linked operation of small-scale hydropower and large-scale power networks is not encouraged. However, where there are conditions appropriate for linked operation of networks, large-scale power networks should provide support;

2. Prices for electricity after linkage of small-scale hydropower and large-scale power networks should be set by the large-scale network according to the principles of no compensation or earnings and reserve profits from supply of electricity for small-scale hydropower in order to support its development. As concerns the specific prices after small-scale hydropower network linkage and the period of mutual compensation for volume of electricity delivered should be determined by each district on the basis of actual conditions and need not strive for uniformity;

3. During the high-water season, both small-scale hydropower and large-scale hydropower within the large power grid should expand seasonal use of electric power to utilize fully this resource and waste less of it;

4. During the high-water season, small-scale hydropower may set preferential prices for electricity on their own and sell low priced seasonal power to peasants and factory and mining enterprises engaged in seasonal production; during seasons when water is scarce, small-scale hydropower should discontinue preferential prices for electricity but large-scale power networks should allocate, according to the plan, the electricity usage targets to rural areas served primarily by small-scale hydropower in accordance with the electricity needs of the area in question.

C. It Is Necessary To Formulate Plans To Develop Small-Scale Hydropower and To Strengthen Management of Existing Facilities To Exploit Potential Fully

On the basis of small-scale hydropower resources, local areas should formulate plans for countywide development of small-scale hydropower stations and rural power networks, select and build in the superior ones, improve design and construction, and upgrade construction quality. Economic responsibility systems should also be implemented in small-scale hydropower construction with contracts, improving efficiency, lowering building costs, and speeding up progress to achieve the best economic results.

For existing small-scale hydropower stations and rural power networks, management should be strengthened, organization and the system of regulations should be improved, economic responsibility systems should be implemented, completion and technological transformation of equipment should be done, personal injuries and deaths should be reduced, and losses in power transmission lines should be reduced to achieve safe and economical supply and use of electricity.

The potential of existing small-scale hydropower stations and water conservancy projects should be fully exploited. An appropriate increase in regulatory reservoirs can expand rated capacity, increase the volume of electricity generated, and improve the quality of electricity of existing small-scale hydropower using cascade dams. For example, if the cascade dam small-scale hydropower on the Chu Jiang in Dayi County, Sichuan, built another reservoir with a capacity of 20 million cubic meters of water, the guaranteed output of the existing power station during dry periods could be increased by over 5,000 kilowatts. Of the water conservancy projects which have been completed but not yet combined with generating electricity, those which have the conditions for utilizing medium- and low-head equipment for generating electricity could get twice the results with half the effort. For example, the Milo Jiang in Pingjiang County, Hunan Province, has seven water conservancy projects to which 30,000 kilowatts could be added or newly installed. From this it can be seen that there is a great deal that can be done in exploiting pontential.

D. It Is Necessary To Pay Attention To Making Full Use of the Seasonal Capacity of Small-Scale Hydropower

The regulatory function of small-scale hydropower stations is generally not great, but during seasons when water is abundant, there is a great deal of seasonal electricity thus, how to utilize fully this seasonal electricity is one of the keys to accelerating the development of small-scale hydropower. Apart from being used in local enterprises which have high power usage and which can engage in seasonal production, such as small-scale aluminum plants, iron alloy plants, calcium carbide plants, yellow phosphorus plants, the main uses of seasonal small-scale hydropower are for peasants to cook and heat water and even for heating and cooling. According to surveys, each kWh of electricity can replace 3-5 catties of wood and it is easy to use, it is clean, and it is very popular with the masses. Last year, in Hunan Province, 800 million kWh of seasonal small-scale hydropower went unused, and if it had been used to replace wood, it could have saved 2 million cubic meters of logs. "Replacing firewood with electricity" can reduce denuding of forests and has important practical significance for protecting vegetation and forests and for water and soil conservation and the ecological balance. Now, nationwide there are many areas where small-scale hydropower has developed well and they are carrying out pilot projects in using electricity for cooking and heating water, and in addition, they have already secured some very good results. On the basis of their actual circumstances, all areas should do what they can to try out this kind of work. At the same time, they should also further develop uses for the seasonal load of small-scale hydropower, such as test manufacture of glass and small-scale agricultural fertilizers. Utilizing seasonal electricity also can improve the number of hours of use of small-scale hydropower and improve the economics of small-scale hydropower. China's hours of use for small-scale hydropower averages only a little more than 2,000 hours, but the hours of use for small-scale hydropower in the United States, Japan, France, Norway and Sweden is over 4,500 hours. If we are to try and find a way to improve the hours of use of small-scale hydropower, it is necessary to utilize seasonal electricity fully.

In addition to this, the experience of foreign countries in the economies of small-scale hydropower, such as standardization and seriation of generator sets, simplification and standardization of plant structures, should be combined with the actual circumstances in our country, then the best chosen for our use to accelerate the development of our small-scale hydropower.

III. Norms for Realizing Our Country's Rural Electrification

Since our economy is still somewhat behind that of the industrially developed countries of the world, the people's standard of living is not high, and supply of electric power is also in rather short supply, our rural electrification must proceed from our actual situation so it can only be rural electrification which is Chinese style and which is on a par with our comparatively well-off standard of living. Recently, the Ministry of Water Resources and Electric Power carried out survey research on Yongchun County in Fujian Province, Cili and Heping Counties in Hunan Province, Longmen County in Guangdong, and Dayi County in Sichuan where small-scale hydropower is rather well developed and set forth some preliminary targets for realizing rural electrification at the county level. They are:

A. Over 90 percent of the peasants countywide should have electricity available for lighting, broadcasting, movies and television.

B. In agricultural production, including irrigation, processing of edible oils, agricultural sideline production processing and commune and brigade industry, electricity should be available.

C. In areas where small-scale hydropower is well developed, about 20 percent of the residents of cities and towns and rural households may use seasonal electricity of small-scale hydropower for cooking and heating water and, where conditions permit, for heating and cooling as well.

According to these norms, each person in a county needs 200 kWh annually, thus, each person needs 100 watts of power supply. We should strive to realize this objective in our country's rural electrification.

Ours is a large country, and economic development is very uneven in both rural areas and the cities. Rural areas where hydropower and hydropower resources are abundant should be encouraged to be the first to realize Chinese-style rural electrification. According to the directive of the leadership comrades of the Central Committee, we are prepared to call a nationwide small-scale hydropower planning conference to select 100 counties where small-scale hydropower resources are abundant and where there is a certain base for generating electricity to formulate development plans, and carry out pilot projects in rural electrification and strive to complete them within 5 years. After we have gained some experience this will then be vigorously extended to the entire country. Of course, other pilot project counties and places which have small-scale hydropower resources also should actively accelerate the development of small-scale hydropower.

Developing small-scale hydropower has earned the enthusiastic support of local areas and the masses and there are excellent prospects for development. We believe that with a correct policy for developing small-scale hydropower and with mass support, our country's small-scale hydropower in the future will develop like bamboo shoots after a spring rain and will play a larger and larger role in realizing the rural electrification of our country.

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SICHUAN IS MODEL OF SMALL-SCALE HYDROPOWER USAGE

Beijing SHUILI SHUIDIAN JISHU [WATER RESOURCES AND HYDROPOWER ENGINEERING] in Chinese No 6, 20 Jun 83 pp 5-6

[Article: "Stipulations by Sichuan Provincial Bureau of Water Conservancy and Power"]

[Text] 1. Sichuan's hydraulic resources are abundant and developing small-scale hydropower is directly related to the two strategic priorities of agriculture and energy so it is necessary to give it sufficient consideration. To develop this superior feature fully all places which have water power resources should, under the overall arrangements of unified planning, actively build small-scale hydropower stations (networks).

To accelerate small-scale hydropower construction in Sichuan, it is necessary to uphold the policy of simultaneous development of large-scale, medium-scale, and small-scale power, and the integration of state-run power and locally-run power. Small-scale hydropower should carry out the primary guideline of "self-construction, self-management, and self-use," the policy of "use electricity to develop electricity," and the mobilization of positive factors for attending to electricity at all levels.

Small-scale hydropower should mainly be self-generated and locally used, striving for a balance in its area, and should be directed mainly towards rural areas and county seats and promote the development of rural electrification to serve agriculture, local industry, and the people's lives in order to envigorate the local and rural economies.

II. Strengthen unified planning and achieve an overall balance of generating, transmitting, distributing and using electricity.

To strengthen unified planning of power networks (stations), do a good job of overall balance and forecasting loads. All local electric power development plans drawn up by cities, local areas, and regions which have a network connection with large-scale power networks should be examined by both the provincial hydroelectric power office and the provincial electric power bureau, approved by the provincial planning commission, and implemented after being made part of the long-range plan and the annual plan.

III. To handle correctly the problem of linked network operations of small-scale hydropower stations (networks) and large-scale networks, on the basis of relevant principles and policies of the Central Committee and the principles of giving consideration to the interests of the central authority, local areas, the collective, and the individual, consider the actual circumstances of Sichuan Province in the past few years and act in accordance with the following stipulations:

A. Construction of small-scale hydropower which must be directly connected with a large-scale power network should sign a network agreement in advance. After the networks are connected, the small-scale hydropower station and small-scale power network's ownership, subordinate relationship, and financial relationship will not change. Power stations constructed within a local small-scale power network which is connected to a large-scale power network will be added to the local electric supply bureau records, with the approval of the section in charge of the local small-scale power network and as long as they do not change the wholesale price of electricity to the price for mutually supplied electricity.

B. Forms of network connection and exchange of electricity:

1. Linked operation of small-scale hydropower stations (networks) and large-scale power networks can adopt any of the following three forms depending on local conditions: linked operation of a single small-scale hydropower station with a large-scale power network which only generates and does not supply electricity; linked operation of a small-scale hydropower station (network) which keeps its electricity to supply its local area; multiple small-scale hydropower stations which, after forming a small-scale power network combine with a large-scale power network in one or several forms.

2. For power stations which only generate but do not supply electricity, electricity generated during periods of low water may be entirely delivered to the network; during periods of high water and depending on the generator situation, power should be delivered to the entire network from 0700 to 2300, and in low demand hours (from 2300 to 0700 the next day) power should be delivered to the network at 65 percent of one-half the volume of electricity generated during the period from 0700 to 2300.

3. For small-scale hydropower stations and power networks which have an electricity supply district and which generate their own electricity and supply their own needs, excess electricity after achieving a balance shall be delivered to the network will still be controlled by the stipulation of 2) above.

4. In periods of low water, large-scale power networks should supply electricity to the small-scale networks on the basis of the local power needs, the capacity of the large-scale power system for supplying electricity, and in accordance with the distribution plan indicators.

C. The power rate of the large- and small-scale power network linkages will be assessed at 0.8, based on active power and idle power which is excessive or insufficient, settled reciprocally at one fen [0433] per kilowatt hour.

D. After large-scale and small-scale power networks are linked, the exchange of electricity will be either on terms of mutual supply or at wholesale prices. Except for important large use customers in national defense industries, large-scale power networks should not attempt to solicit customers within the small-scale power network. The supplier of the electricity is responsible for the customers.

E. In order to maintain the relative integration of large-scale and small-scale power networks and to be favorable for strengthening management, the countries (municipalities, regions) where large- and small-scale power networks intersect in electricity supply may carry out appropriate readjustment, decide on the specific method through negotiation, and it will first be tried out in the Wenjiang district.

F. Calculation of electricity expenses and prices for mutually supplied power: in accordance with the relevant stipulations in demarcation of property rights both parties in a linked network power station (network) shall install instruments to measure the kWh to serve as a basis for calculating power expenses. If for 6 months out of the year the generating capacity of small-scale power networks continues to be greater than the load of electricity used (apart from exceptional factors such as accidents), it may be resupplied to the large-scale power network, and viewed as mutual supply using one price for both transmission and reception. The accounting of power will be based on the active and idle dispatch curves, and assessed at 0.8 of the network junction point power rate, with 5 fen for each kWh of the active portion, and 1 fen for each kWh of the idle excess or shortage. For small-scale networks which must have electricity supplied by a large-scale power network for more than 6 months of the year, different prices for electricity will be charged, after being adjusted seasonally, for the active portion, small-scale power networks will provide large-scale power networks 5 fen for each kWh, for what large-scale power networks send to small-scale power networks the overall electric rate discounted by 30 percent will be used, and for the idle excess portion it will be calculated on the basis of 1 fen. For electricity from local power stations with network connections but which only generate electricity and do not supply it, the power rate will be assessed according to the make of generator, with active at 5 fen per kWh, and excess or insufficient idle at 1 fen per kWh. Small-scale power stations with network lines specially used for transfer operations will be calculated at 1 fen 5 li per idle kWh.

G. In the case of small-scale hydropower which is currently directly connected with a large-scale power network but only generates electricity and does not supply it, if in the future the local area builds a mainstay power station which has the capacity to supply electricity to the area for industrial and agricultural production and the daily lives of the people, it may actively expand its load, and through negotiation, and after approval of the provincial planning commission, the large-scale power network also can divide the local load and let the small-scale hydropower station (network) supply electricity directly, generating and supplying electricity, but still maintain the linkage relationship with large-scale power network, with each making up the other's deficiency.

H. For power stations built in connection with water conservancy projects, the quantity of electricity supplied to the network and the rate for the electricity after connecting with the network also will be handled according to these stipulations.

IV. Strengthen management of small-scale hydropower stations (networks), strengthen readjusting loads and saving electricity, develop seasonal loads, and fully develop the results of existing equipment.

A. Presently some small-scale hydropower supply regions which have electricity to spare. The results of trials in using electricity to replace wood by expanding the use of electricity for making tea, curing tobacco, drying, raising rice seedlings, incubation, cooking, and heating water, should be summarized and gradually popularized, and begin especially to utilize the electricity of slack periods (2300 to 0700 the next day daily) as much as possible.

B. To rationally adjust loads, in addition to strengthening planned use of electricity, the policy of a floating rate structure for electricity for high water and low water periods and for peak and slack periods may be implemented. The floating rate structure will be set by governments at all levels.

V. Other policies for developing small-scale hydropower.

A. Profits from enterprises which are subordinate to the county and below county level which retail electricity, and profits from the generation and supply of small-scale hydropower will not become added to general revenues, but will be used to "use electricity to develop electricity" and will be used entirely for local electric power (counties which are carrying out financial contracts should exclude these funds from the contract figures).

B. In view of the fact that the one time investment in small-scale hydropower is large and the investment return period is long, we propose that banks provide long-term low interest loans for small-scale hydropower construction.

C. Commune and brigade power stations should pay taxes in accordance with existing state policies. Commune and brigade power stations which are having economic difficulties may request local revenue sections to lower or eliminate taxes, which may be approved after reporting to county level revenue departments and securing approval from upper echelons.

D. The three materials, equipment, and labor quotas necessary for building and managing small-scale hydropower stations (networks) should be made part of the annual plan.

VI. From now on, problems which appear between small-scale hydropower stations (networks) and large-scale power networks will be discussed and resolved by provincial water conservancy (hydropower) and electric power departments on the basis of the principles of these stipulations.

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UNIQUE NATURE OF 'CHINESE-STYLE' SMALL-SCALE HYDROPOWER DEVELOPMENT

Beijing SHUILI SHUIDIAN JISHU [WATER RESOURCES AND HYDROPOWER ENGINEERING] in Chinese No 6, 20 Jun 83 pp 7-11

[Article by Xiao Dianhua [5135 7193 0553]: "The Development of Small-Scale Hydropower and Its Characteristics in China"]

[Text] Small-scale hydropower is an important energy source in the rural areas and plays a very big role in promoting rural electrification and realizing agricultural modernization. Recently, while inspecting small-scale hydropower in Fujian Province, leading comrades of the Central Committee clearly said that beginning now, in 5 years' time 100 pilot project counties which are fundamentally electrified should be built to welcome the next party congress. The important speeches by leading comrades of the Central Committee have enlightened and encouraged small-scale hydropower workers. To realize Chinese-style rural electrification as quickly as possible, we would like to discuss our views on some problems related to the development of our small-scale hydropower.

I. China Has Abundant Small-Scale Hydropower Resources

China's territory is vast and there are numerous rivers: there are over 5,000 rivers with valleys which exceed 100 square kilometers in area, and in addition to the main rivers, medium and small branch rivers are distributed all over the country. According to survey materials China's small-scale hydropower resources are very plentiful, with theoretical reserves of 150 million kilowatts, and corresponding annual generating output of 1.3 trillion kWh (including exploitable resources of 7 million kilowatts, or an annual generating output of 200-250 billion kWh). Presently, the small-scale hydropower resources which have been developed only amount to 11 percent of all the small-scale hydropower resources, therefore, the small-scale hydropower resources yet to be developed (see Table 1) are considerable.

There are two characteristic features of China's small-scale hydropower sources: One is that the reserves are great and broadly distributed. Of the more than 2,300 counties in the entire country, the exploitable resources of small-scale hydropower in 1,104 counties exceeds 10,000 kilowatts (including over 470 counties of 10,000-30,000 kilowatts, 500 counties which could reach 30,000-100,000 kilowatts, and 134 counties which could reach more than

Table 1. Distribution and Development of Small-Scale Hydropower Resources

Region	Small-scale hydropower resources: Theoretical reserves (10,000 kW)	Exploitable resources (10,000 kW)	Percent	Resources exploited: Installed capacity (10,000 kW)	Percent	Developed exploitable resources (percent)
Southwest	6,860	3,338.2	46.8	182.1	22.6	5.5
Northwest	2,810	936.0	13.1	47.6	5.9	5.1
South-Central	3,151	1,554.2	21.8	341.7	42.3	22.0
East China	1,438	942.4	13.2	195.3	24.2	20.7
North China	462	164.1	2.3	22.8	2.7	13.9
Northeast	297	196.3	2.8	18.5	2.3	9.4
National	15,000	7,131.3	100	808.0	100	11.3

100,000 kilowatts). The second is that the reserves are mostly concentrated in areas which are outside the scope of large-scale power network supply. Seen from the perspective of the entire country, the districts with small-scale hydropower resources can be divided into the following four areas:

1. The Chang Jiang valley and the 10 provincial regions of Fujian, Zhejiang, Jiangxi, Hunan, Hubei, Guangdong, Guangxi, Sichuan, Yunan and Guizhou to the south which are largely mountainous areas where rainfall is plentiful and rivers are steep. Exploitable small-scale hydropower resources are about 40 million kilowatts, making up 57 percent of the small-scale hydropower resources of the entire country, and of the 932 counties in these 10 provincial regions, small-scale power resources exceed 10,000 kilowatts in 749 of them, so this is an important area for China's development of small-scale hydropower resources in the future.

2. The seven provincial areas of Henan, Shandong, Anhui, Shaanxi, Gansu, Ningxia, and Qinghai which are between the Chang Jiang and the Huang He and are situated on the Huang-Huai-Hai Plain and the Northwest loess plateau where the climate is dry, the earth slopes gradually, and small-scale hydropower resources are fewer. According to surveys, exploitable small-scale hydropower resources are 6.5 million kilowatts, including small-scale hydropower resources in excess of 10,000 kilowatts in 135 counties.

3. The Xizang and Xinjiang territories are vast, situated at the foot of the Himalayas and the Tianshan respectively, the mountains are high and steep and always snowcovered and are places where water power resources enjoy exceptional advantages. There are about 20 million kilowatts of exploitable small-scale hydropower resources here and all the counties in Xizang and a large part of the counties in Xinjiang have exploitable small-scale hydropower resources in excess of 10,000 kilowatts. For this reason, this area also will be a key area for development of small-scale hydropower.

4. In the north China and east China region north of the Huang He, there are not many medium-sized and small-sized rivers and hydraulic resources are only concentrated in a few isolated areas, thus the exploitable small-scale hydropower resources are only about 3.56 million kilowatts, or only about 5 percent of the national total. Although the small-scale hydropower resources in this area are few, they are concentrated, distributed mainly at the eastern and western foot of the Taihang Mountains, in the eastern portion of Liaoning and Jilin Provinces, and in the Daxing-Anling forest area of Heilongjiang Province. For this reason, there are nearly 100 counties which have exploitable small-scale hydropower resources in excess of 10,000 kilowatts.

Three surveys have been conducted on China's small-scale hydropower resources, but since the characteristics of small-scale hydropower have many features, are scattered and involve a very large area, the survey work has been enormous and thus still awaits further improvement and verification. Starting in 1981, the Jilin Province Department of Water Conservancy spent 1 year and 3 months conducting another comprehensive survey of the province's medium and small sized rivers. The results of the survey showed that the small-scale hydropower resources were 1.3 million kilowatts, or nearly double the 690,000 kilowatts of the 1979 survey. If provinces and regions could conduct a more comprehensive and thorough survey, the index of China's small-scale hydropower resources might increase over the volume of theoretical reserves which have already been made public.

II. The Development and Characteristics of China's Small-Scale Hydropower

China was one of the first countries in the world to utilize water power, but China was definitely late in starting to utilize water power to generate electricity. China's first hydropower station was the Shilong Dam Power Station near Dianchi in Kunming, Yunnan Province, which was started in 1908 and officially began to generate electricity in 1913 but the rated capacity was only 500 kilowatts (later expanded to 2,300 kilowatts). Up to the eve of the founding of the PRC in 1949 the rated hydropower generating capacity nationwide was only 260,000 kilowatts (including 2,800 kilowatts of small-scale hydropower rated capacity). With the development of China's socialist enterprise, the rate of small-scale hydropower construction has also accelerated. In the fifties, the annual increase in small-scale hydropower rated capacity was only several thousand kilowatts; in the sixties, the annual increase in small-scale hydropower rated capacity was several tens of thousands of kilowatts; in the seventies, the annual increase in the rated capacity of small-scale hydropower was in hundreds of thousands of kilowatts; since the 3d Plenary Session of the 11th Party Central Committee in particular, the rated capacity of small-scale hydropower has increased 2.82 million kilowatts, an average annual increase of 700,000 kilowatts. Up to the end of 1982, over 80,000 small-scale hydropower stations had been built nationwide, with a total rated capacity of 8.08 million kilowatts, more than 3 times the total capacity of hydroelectric and thermoelectric equipment in 1949. Presently, over 1,500 counties nationwide have exploited small-scale hydropower resources, with 774 counties relying mainly on small-scale hydropower for electricity, or one-third of all the counties across the nation; 20,000 people's communes rely on small-scale hydropower for electricity, or about 40 percent

of the total number of people's communes across the nation. According to statistics, for 1982 alone the volume of electricity generated by small-scale hydropower was 17.2 billion kWh, or one-third of the volume of electricity used by agriculture nationwide in that year.

Through many years of practice, China has developed and trained a technical contingent capable of building and managing small-scale hydropower. In counties in which small-scale hydropower is concentrated in particular, generally local forces can be relied on to undertake survey, planning, design, construction, and operations management. In addition to this, China also has considerable ability to manufacture small-scale hydropower equipment, having nearly 100 state-owned plants to manufacture small-scale hydropower main generator equipment, which can annually produce small-scale hydropower generator groups of over 1 million kilowatts. To accelerate the growth of China's small-scale hydropower, the Ministry of Machine Building Industry and the Ministry of Water Resources and Electric Power together developed seriation and uniform standards for small-scale hydropower generators, so now nationwide there are 26 standard models and 83 varieties of hydraulic turbines, with a head application range of 2.5-400 meters, and a single generator capacity ranging from several kilowatts to 10,000 kilowatts.

China's experience in building small-scale hydropower has been noticed and praised internationally. Since 1980 the United Nations has twice convened international small-scale hydropower conferences in Hangzhou and has decided to raise funds and construct an Asian and Pacific Region international small-scale hydropower training center in China. At the international small-scale hydropower conference, the officers and national representatives of the UN Industrial Development Organization [?] felt that China's small-scale hydropower construction had accumulated experience which had Chinese characteristics. This is mainly manifested in the following areas:

1. In terms of policy, it relies on county, commune, and brigade forces to operate electrical facilities, with the government providing positive support so that motivation for developing small-scale hydropower can be combined from top to bottom.

2. In terms of planning, it carries out comprehensive development of medium and small rivers, combining flood prevention, generating electricity, irrigation, and transportation and utilizing water resources fully.

3. In terms of engineering, it advocates suiting measures to local conditions, fully utilizing local materials for building hydraulic structures, and promoting prestressed concrete pressure pipes and concrete electric poles.

4. In terms of equipment, they are based in manufacturing complete sets of equipment locally, and have already developed seriation and standardization of small-scale hydraulic turbine generator groups.

5. In terms of management, they are based in local management of small-scale hydropower stations and small-scale hydropower networks, and implement unified management of generating, delivering and using electricity, are responsible for profit and loss, and have developed the benefits of small-scale hydropower.

6. During periods of abundant water seasonal small-scale hydropower is used in the manufacture of such industrial products as nitrogenous fertilizer, electrolytic aluminum [?], carbide, and ferroalloys which require high consumption of electricity.

7. They have adopted a variety of measures to reduce the cost of producing small-scale hydropower.

The above characteristics and experience have not only been praised internationally, but also have built an excellent material and technological foundation for Chinese-style rural electrification.

III. The Results of China's Small-Scale Hydropower Become More Evident Daily

China's small-scale hydropower development has entered a new period. The characteristic of this period is that we have further developed from using electricity for illumination, processing and industry to comprehensive electrification.

Experience of many years now proves that developing small-scale hydropower is an important part of promoting the building of a spiritual and material culture in the mountainous regions and in the rural areas generally. Judging from a nationwide survey, as long as it is managed properly, if a county in a mountainous area can start up 10,000 kilowatts of small-scale hydropower, great changes can take place in this mountain county. Summing it up, the main benefits of small-scale hydropower are:

A. County and commune industry enjoyed greater development.

Calculated on the basis of a small-scale hydropower of 10,000 kilowatts in one county, the annual value of output of county industry could reach more than several million yuan, and could even exceed 100 million yuan, which is 2-3 yuan of value of industrial output per kWh. Over the past 10 years, Hengdong County in Hubei has built 35 small-scale hydropower stations with a rated capacity of 23 million kilowatts and since they had abundant and inexpensive electric power, the industrial and mining enterprises operated by the county developed very quickly and in 1981 alone, the value of industrial output for the entire year was 6.6 million yuan and the value of the output of commune and brigade enterprises was over 3 million yuan. Therefore, in some counties and mountainous areas, people call small-scale hydropower the center of the rural industry.

B. The development of agricultural mechanization and electrification was promoted.

Small-scale hydropower is an advanced energy source for motive power and generally a county with more than 10,000 kilowatts of small-scale hydropower forms its own small-scale power network and can basically have over 60 percent of the production brigades start using electricity and realize the preliminary mechanization of agricultural sideline product processing.

C. Bringing all farmland under irrigation is promoted.

Utilizing small-scale hydropower to develop electrically powered irrigation has improved the ability of farmland to resist drought and to drain flooded areas and has promoted the bringing of farmland under irrigation. Enping County in Guangdong Province comprehensively developed the Jin Jiang, the important river in the county, and at the same time that they built small-scale hydropower stations on the steps, they brought in water to irrigate 280,000 mu of farmland on both sides of the river, and on the lower reaches used electricity to drain 120,000 mu so that the arid and the easily flooded arable land enjoyed bumper harvests.

D. It is favorable for accumulation of funds by local areas and communes and brigades.

According to survey materials, the profits of small-scale hydropower in Guangdong Province in 1980 alone, were 27.6 million yuan (13 million yuan was used for small-scale hydropower construction, 9.5 million yuan are used to support farmland water conservancy construction, and 5.1 million yuan was used for county and commune industrial enterprise investment). Xinchang County in Zhejiang Province has altogether 210 small-scale hydropower stations with a rated capacity of 26,000 kilowatts and since the supply of electricity is sufficient, industrial and agricultural production have developed rapidly and the value of industrial and agricultural output has grown very quickly (see Table 2).

Table 2. Value of Industrial Output and Taxes of Xinchang County's Small-Scale Hydropower

Year	Small-scale installed capacity	Value of industrial output (10,000 yuan)	Taxes provided by industry (10,000 yuan)
1977	5,016	4,776	283.1
1978	7,269	6,016	376.5
1979	10,974	8,638	468.5
1980	17,697	11,369	509.2
1981	26,117	13,500	600

E. The material and cultural standard of living of peasants in mountainous areas has improved.

When a mountainous rural area has electricity, not only does it allow the broad peasants to begin to use electric lights, but also can develop television and broadcasting. Since people's communes operate cultural facility and build cinemas, the cultural standard of living of the mountain area peasants is enriched and the construction of a spiritual culture promoted. In the past few years in particular, peasants have begun to use excess seasonally generated electricity to expand electric heating and to replace firewood with electricity and have obtained some delightful results.

IV. The Reliability and Economics of Small-Scale Hydropower

At present, China's energy supply is rather tight and the shortage of energy in the rural areas is especially acute. For this reason, nationwide rural areas annually burn over 100 cubic meters of wood and 500-600 billion catties of straw (approximately 70-80 percent of all the straw). In addition, according to statistics, over 40 percent of the production brigades and 50 percent of the rural households in China do not yet have electricity. Therefore, from the perspective of the rational use of energy, "every flowing stream is coal and oil," "one small-scale hydropower station is equivalent to a small oil well, and many small-scale hydropower stations are equivalent to a large coal mine." Thus it is very necessary to develop more small-scale hydropower.

Under ordinary circumstances, since small-scale hydropower is mostly built on medium and small sized rivers, water storage projects are few, capacity to regulate runoff is deficient, the capacity of power stations is small, and in addition some power stations are still not sufficiently perfected managerially, thus reliability is somewhat less than that of large-scale power stations. However, with the growth of small-scale hydropower construction, its reliability will also improve. This can be confirmed from the following five aspects:

A. In the fifties, the rated capacity of small-scale hydropower stations was still only 500 kilowatts, by the sixties the rated capacity of a single generator was 3,000 kilowatts, in the seventies it was 12,000 kilowatts, and in the early eighties, the capacity of a single station will grow to 25,000 kilowatts. Since the scale of small-scale hydropower stations is gradually increasing, today's "small" is already yesterday's "large."

B. Much small-scale hydropower has formed local small-scale networks and from the single station operation and decentralized supply of electricity of the past have developed into unified small-scale power networks for the supply of electricity.

C. Through the construction of mainstay small-scale hydropower stations which have reservoirs with regulatory capabilities, this has progressively improved the guarantees of power during dry periods.

D. Due to the strengthening of scientific management, managerial work of small-scale hydropower has grown from the past single station management to unified management at the county and local level. Concentration of management has made generation, supply, and use of electricity more economically rational.

E. Under the principal of voluntary network connections, small-scale power networks which are close to large national power networks combine operations with large-scale power networks and regulate each other so that the insufficient electric power of small-scale hydropower during dry periods can be supplemented.

The economies of small-scale hydropower can be explained by the three following aspects:

A. Funds for small-scale hydropower construction come mainly from funds raised by the masses and various levels of local government, with the state providing subsidies of only about 300 yuan per kilowatt. Viewed in terms of the volume of state investment, unit per kilowatt investment in small-scale hydropower is only 40 percent of the unit per kilowatt investment in large and medium sized hydropower stations.

B. Small-scale hydropower can build stations using local materials, supply electricity to nearby areas, and adapt to the decentralized electricity use needs of rural areas.

C. Small-scale hydropower is rarely flooded so in some cases there is not even any problem of flooding. Thus, some difficulties which arise in excavation are reduced but what is more important is construction costs are lowered and the rate of construction is accelerated.

In 1981, Sichuan compiled some statistics on costs of state power networks, small-scale thermopower and small-scale hydropower in supplying power to rural areas (see Table 3). The results show that costs of selling small-scale hydropower are only 50 percent of those for small-scale thermopower and 62 percent of those for state power networks.

Table 3. Costs of Rural Power Supply in Sichuan for 1981

Power source	Small-scale hydropower	Small-scale thermopower	National grids, power bureaus	Totals
Number of power stations	304	13	36	353
Installed capacity (10,000 kW)	37.3	3.98	16.7	--
Power generated (100 million kWh)	13.98	1.09	5.84	--
Hours of generating power	3,849	2,751	--	--
Costs of generating power (yuan/1,000 kWh)	17.39	69.80	--	--
Costs of selling power (yuan/1,000 kWh)	50.0	100.2	80.3	64.2

V. Planning for Rural Electrification

Recently, with regard to the problem of small-scale hydropower construction, leadership comrades of the Central Committee reiterated that resolving the problem of energy for the production and daily lives of the people in counties where hydropower and coal resources were especially abundant should concentrate efforts on small-scale hydropower and small-scale thermopower and should not undertake other kinds which divert limited materiel, finance, and manpower because after all, after a few years the other kinds can also be used for electricity. Electrification is a stage which human society must go through,

something all countries must do: some already have, and in the next century probably all countries in the world will. We are doing rural electrification by starting with small-scale hydropower; this general direction is already clear.

For basic electrification in China's rural areas, first of all electrification plans should be made. Thus, the following problems must be clarified:

A. The principles of Chinese-style rural electrification.

1. On the basis of the actual situation in China today with shortage of energy and shortage of electricity in large-scale networks, in terms of electricity sources, China's abundant reserves of small-scale hydropower resources should be relied on in the main.

2. Construction should be done by local areas and communes and brigades carrying out the three selfs policy of "self-construction, self-management, self-use"; funds should be those raised by the local areas and the masses themselves with the state providing appropriate subsidies; after construction, the local management system of "unity of construction and management" and "unity of generating electricity and supplying electricity" should be carried out.

3. Level of electricity use should correspond to that of an expected well-off standard of living.

The above three points are fundamental principles which China has followed in small-scale hydropower construction for many years now and if we depart from China's national circumstances, electrification will be impossible.

B. The level of Chinese-style rural electrification.

The original idea of the level of electrification which must be reached in 5 years, i.e., by 1987 was:

1. Over 90 percent of the homes in a county will have electric service, using it for illumination, broadcast radio, watching television, and showing motion pictures, and part of the middle and elementary schools will use electrification to develop culture and education.

2. Over 20 percent of the homes in a county will be able to use electricity for cooking and heating water for more than half the year and over 50 percent of the homes will be able to use electricity for air blowers and electric fans for cooling.

3. Agricultural sideline processing, such as hulling rice, polishing, pressing oil, making wine, and grinding fodder will basically be electrified.

4. Agricultural production, including small-scale irrigation, shelling, threshing, killing insects, raising seedlings, shearing sheep, automated poultry raising and drying grain, will basically be electrified.

5. The electrical needs of county run industry and commune and brigade enterprises will basically be satisfied.

On the basis of the level of electrical usage described above, it is estimated that the amount of electricity needed annually per person is about 200 kWh, or about 100 watts of power supply per person. However, taking into account the limitations of natural and economic conditions under which county and commune industry suffer, the development of the counties will be very uneven and the volume of electricity they need will not entirely match the population, therefore in counties with larger populations the volume of electricity needed per person will often be lower than 200 kWh. According to figures from 100 pilot project counties chosen earlier: the 100 pilot project counties had a total population of 32 million and exploitable small-scale hydropower resources of 9.4 million kilowatts, or 290 watts of resources per person (1.44 million kilowatts of capacity has already been developed, or 45 rated watts per person).

C. Economic analysis and balanced usage.

The method of electrification planning is primarily based on stressing a balance of water resources, a balance of electric power and output, and dynamic economic analysis. This is the basic method of electrification planning and the criterion for measuring its results. However, in small-scale hydropower planning and design in the past, the above work was frequently overlooked and thus there is a certain amount of blindness in construction which brings losses to the project and these lessons of experience should be heeded.

The electric use load is the foundation of electrification planning and good estimates of electrical use loads should be made on the basis of national economic development plans and agricultural regional plans; not only should the gross total of load need be estimated, but the characteristics of the load should be analyzed and annual and daily load curves be drawn. After that, a power amount balance should be done for a representative year of the planning level after balance of water resources and electrical resources development proposals be proposed on the basis of the balance and economic calculations. Only through balanced calculation can construction proposals be developed for the necessary increase in electric capacity at the smallest consumption of investment.

D. Small-scale hydropower forecast for the year 2000.

In order to realize the great goal of quadrupling the gross production value of the national economy by the year 2000, it is necessary to firmly stress energy construction and since small-scale hydropower also concerns regenerating energy for the production and daily lives of several hundred million peasants, it should be even more advanced. Preliminary estimates are that by the year 2000, the installed capacity of small-scale hydropower will be 25 million kilowatts, or about one-third of all exploitable resources.

To sum up, realizing Chinese-style rural electrification not only is something which can be done in the near term, but also indicates that small-scale hydropower has broad prospects for development.

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PROFUSION OF SMALL-SCALE HYDROPOWER STATIONS BOOSTS RURAL ELECTRIFICATION EFFORT

Beijing SHUILI SHUIDIAN JISHU [WATER RESOURCES AND HYDROPOWER ENGINEERING] in Chinese No 6, 20 Jun 83 insert

[Text] The development of small-scale hydropower in Guangdong Province has been rather rapid. Guangdong has a total small-scale installed capacity of 1.22 million kilowatts, the first province in the nation to exceed 1 million kilowatts.

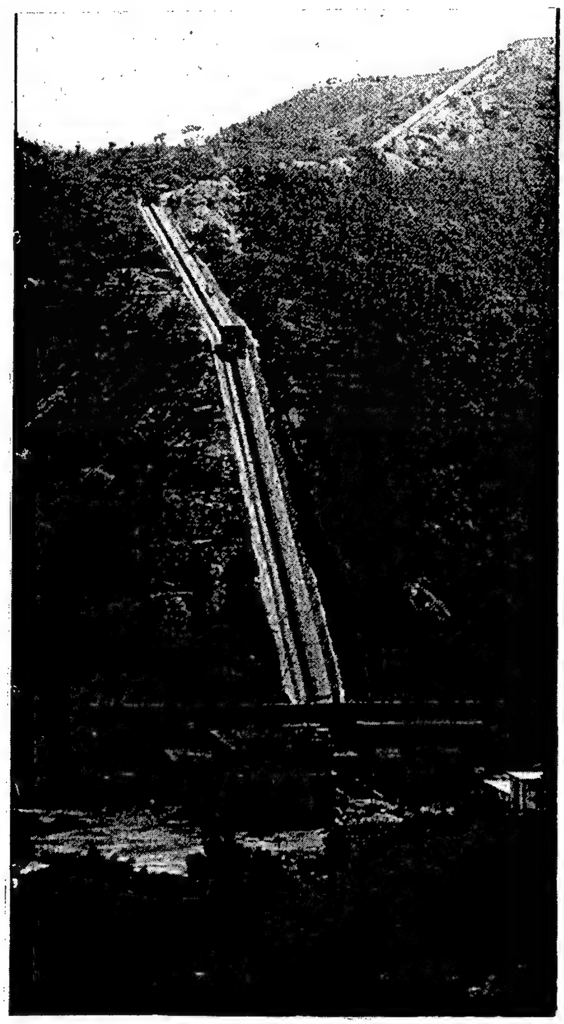
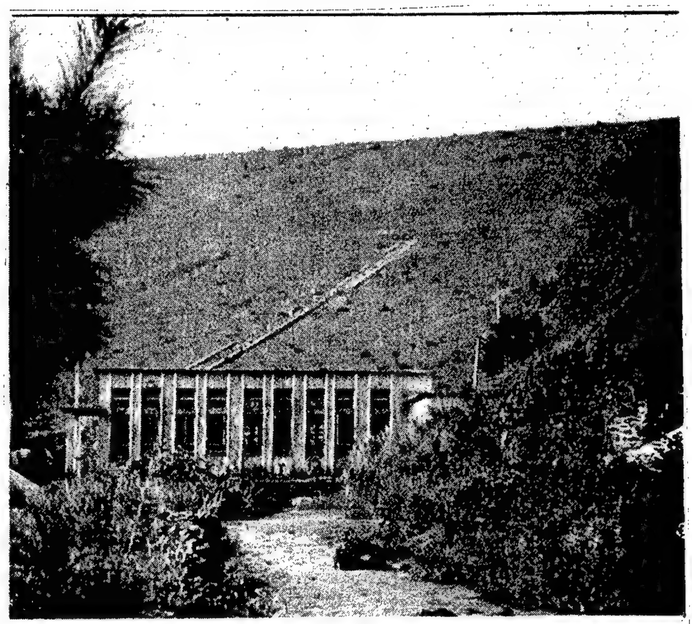


Fig. 1. The hydropower station at Hetian, Puning County, Guangdong Province.



广东省惠阳县碗窑水库水电站

Fig. 2. The hydropower station at Wanyao Reservoir, Huiyang County, Guangdong Province.

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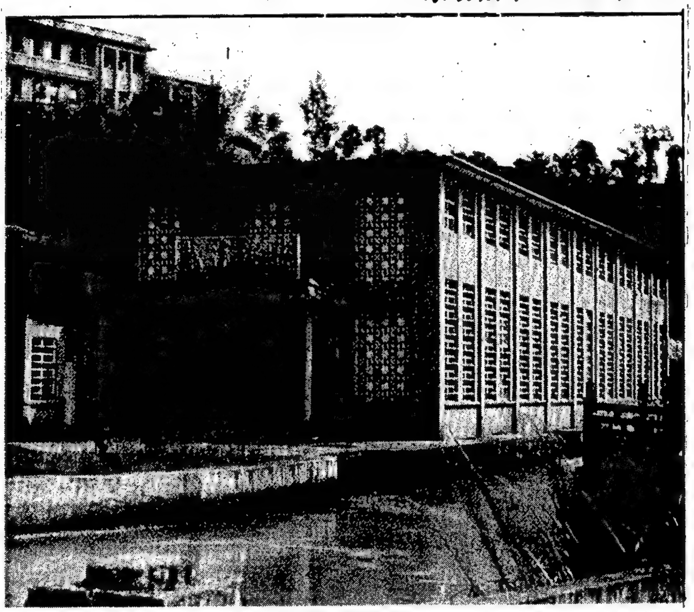

Fig. 3. The Longtan Hydropower Station, Lufeng County, Guangdong Province.

China has rich hydraulic resources and approximately 70 million kilowatts of the theoretical reserve of 150 million kilowatts can be developed. As of the end of 1982, more than 80,000 small-scale hydropower stations had been built throughout the nation with a total installed capacity of 8 million kilowatts and a yearly output of 16.3 billion kilowatt-hours of electricity. The active development of small-scale hydropower is a strategic measure to resolve the problems of rural energy resources, rural construction, and the preservation of forests.

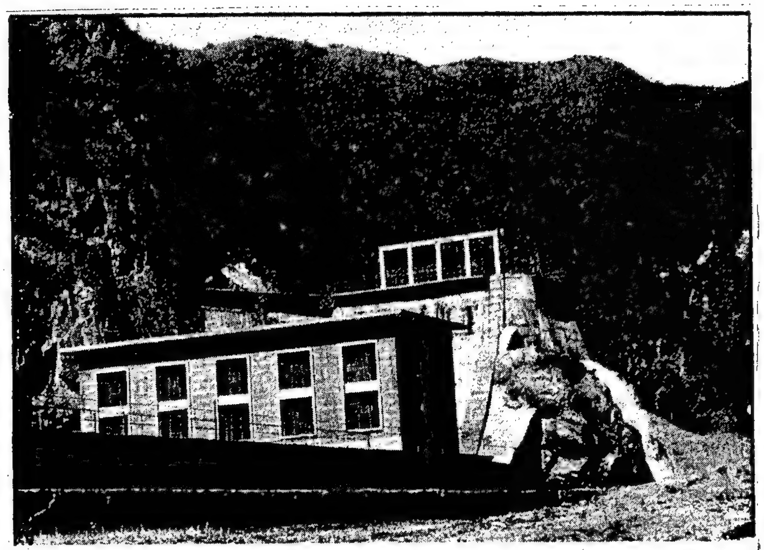

Fig. 4. The Baoshansi Hydropower Station, Huairou County, Beijing Municipality.

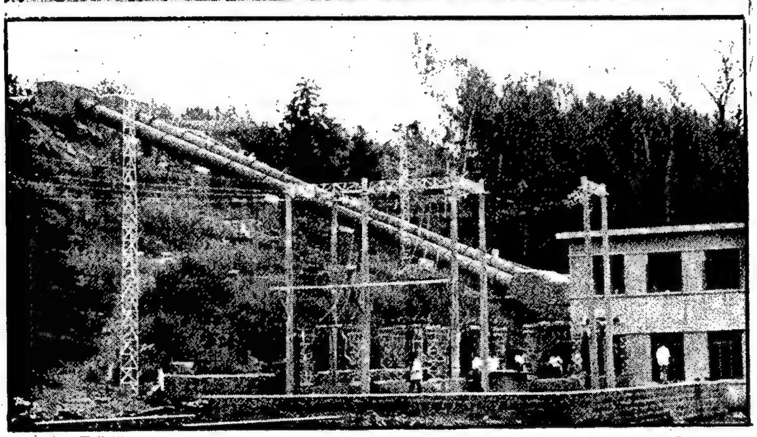

Fig. 5. The Erdaobaihe Hydropower Station, Antu County, Jilin Province.

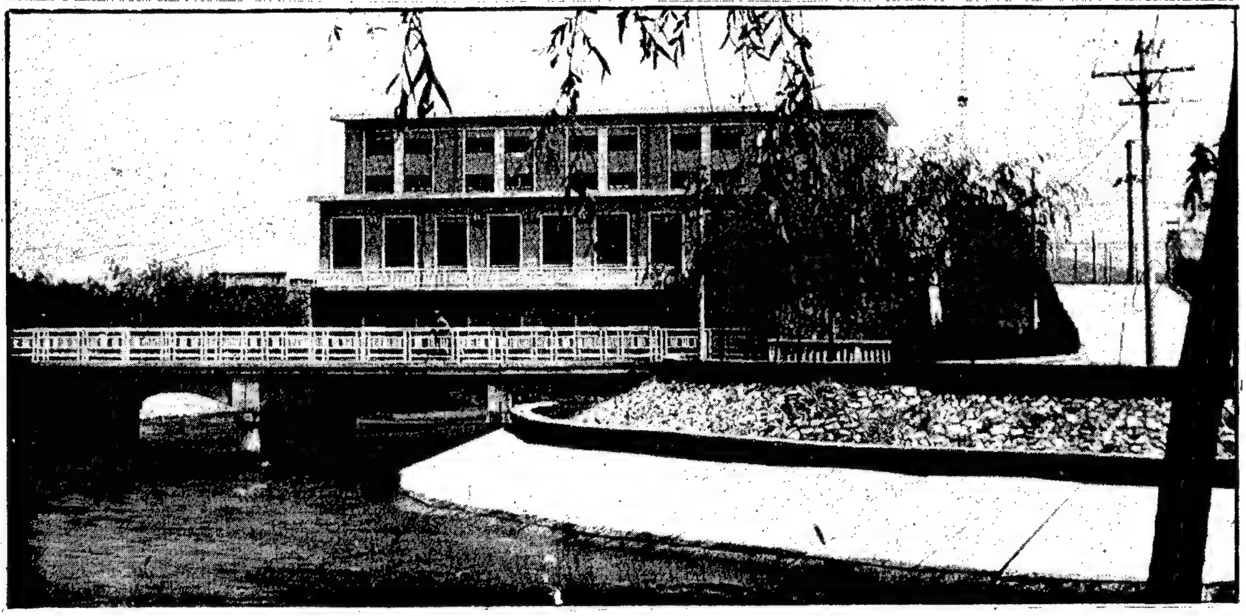

Fig. 6. The second stage hydropower station of the Beijing-Miyun water diversion project, Beijing Municipality.

Fig. 7. The Chongyi small-scale hydropower station, Guan County, Sichuan Province.

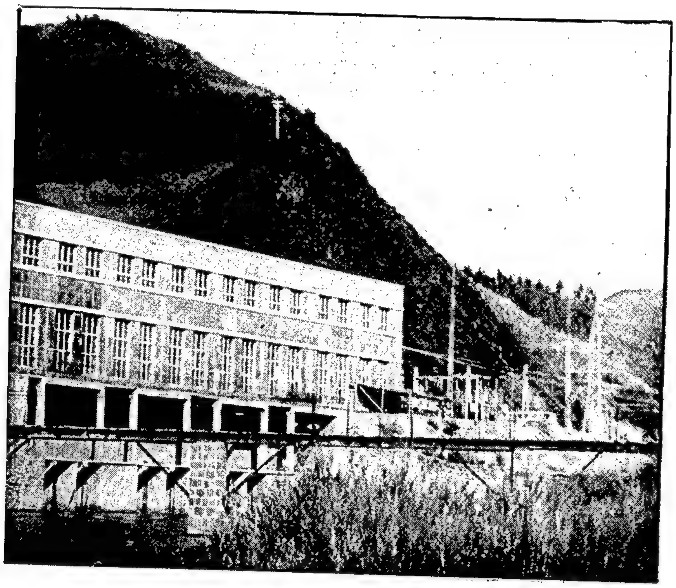

Fig. 8. The Bei Jiang Hydropower Station, Fusong County, Jilin Province.

Yongchun County in Fujian Province is located on the upper reaches of the Jin Jiang in southern Fujian. Two hundred fifty-two small-scale hydropower stations have already been built in the county for a total installed capacity of 23,321 kilowatts. All of the county's related units, people's communes, and production brigades, as well as 99 percent of the production teams have electricity.

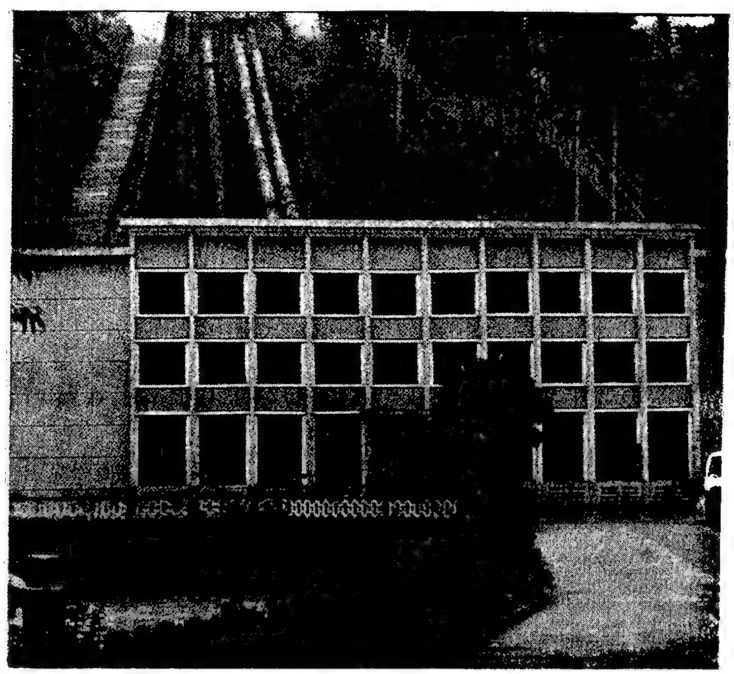

Fig. 9. The Qingyuan Hydropower Station.

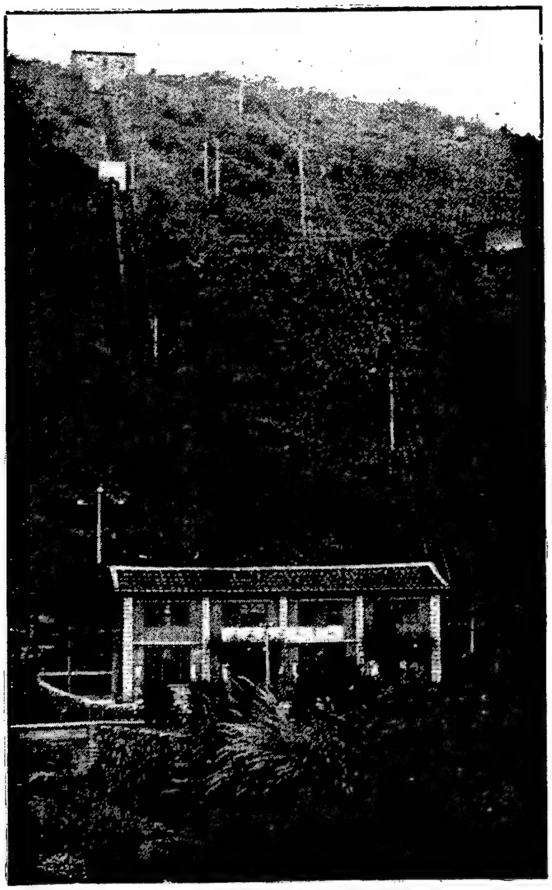

Fig. 10. The Qingxiban Hydropower Station. ←

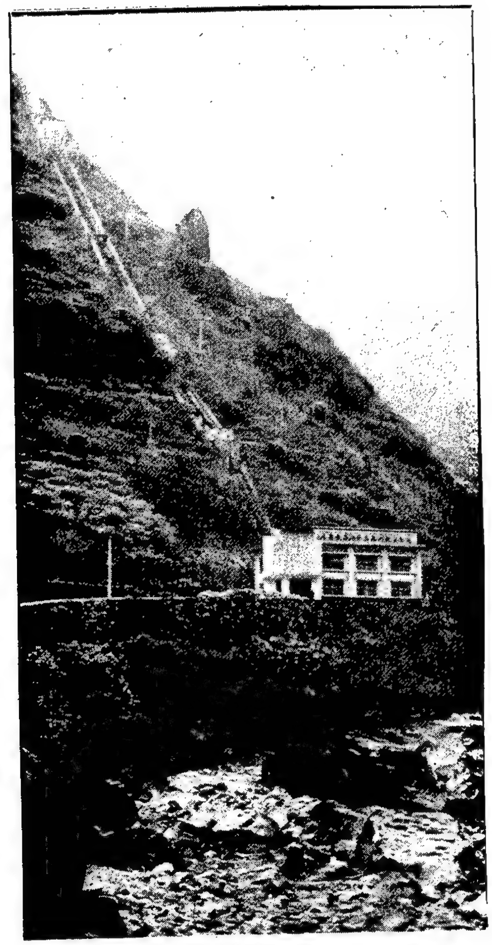

Fig. 11. The Matiao first stage hydropower station. →

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APPROACH TO RURAL ELECTRIFICATION PLANNING AT COUNTY LEVEL

Beijing SHUILI SHUIDIAN JISHU [WATER RESOURCES AND HYDROPOWER ENGINEERING] in Chinese No 6, 20 Jun 83 pp 12-18

[Article by Bai Lin [4101 2651] and Li Ying [2621 3576] of the Rural Electric Office of the Ministry of Water Resources and Electric Power: "A Planning Approach to Chinese-Style Rural Electrification at the County Level"]

[Text] The leading comrades of the Central Committee take the development of small-scale hydropower very seriously and have proposed selecting 100 counties which have abundant water resources and the foundation of developing small-scale hydropower to serve as pilot projects in Chinese-style rural electrification. So that this planning will be done well, as a result of surveying electrification planning in Yongchun County, Fujian Province, and summarizing the planning situation of some other counties we propose some general views on planning approaches to developing Chinese-style rural electrification to provide materials for reference.

I. Preplanning Foundation Work

A. Collecting information on the basic situation

The basic situation can be divided into the natural situation, the socioeconomic situation, and the resources situation. When collecting the above mentioned materials, the four following problems must also be explained:

1. The population and the number of households are basic data of the time of planning and estimating the population and number of households 5 years hence should take into account the annual growth rate, which can generally be calculated at an annual average rate of 1.0 - 1.4 percent.

2. When collecting information on the value of industrial and agricultural output and growth rates of plants, enterprises, and rural communes subordinate to the county, the value of the output of those factories and mines and enterprises which are subordinate to the central government, province or region and are within the borders of the county but which are not part of the county's electric supply network should be calculated separately.

3. When surveying the number of households lacking firewood countywide, the number of households lacking firewood for more than 4 months and less than 4 months should be separately calculated as a proportion of the total number of households in the county. In addition, households which live in forested areas generally are not without firewood, but the quantity of wood burned by each household annually should also be calculated as an indication of the future social benefits of "replacing firewood with electricity."

4. All counties should conduct surveys of their water power resources and those areas which have drainage area plans which are over 10 years old should conduct another survey. For example, after Jilin Province resurveyed the province's water power resources, exploitable water power resources more than doubled over the original survey.

B. Survey of the present level of electrification

The content of the survey of the present level of electrification can be divided into three parts: power sources, power networks, power usage. At the time of the survey, the following three areas should be stressed:

1. For many reasons, among existing power stations, a certain number have problems involving capacity. These problems, which prevent generators from achieving rated power output, should be tackled and resolved separately.

2. The existing load situation of households with electric service should be conscientiously surveyed and clearly marked on a county geographical junction map.

3. The precision of the load categories will have an impact on the estimates of load and the balance of volume of power at the time of planning. Thus, electrical use for county run industry, commune and brigade enterprises, agriculture, and for domestic purposes should be classified and categorized by load for each classification.

II. Estimating Load

In estimating load, two principles should be made clear, viz., the scope of electrical supply and the balance of planned loads.

A. Selection of levels of rural electrification

In setting the 1987 level of rural electrification, the following may be used for reference:

1. In implementing the norms for the shortest period of time electricity can be used for cooking, counties can determine this in the light of power output of power by the county's hydropower stations during high water period of regulatory power stations. However, generally, the time should not be less than 6 (consecutive) months. At the same time, the number of households using electricity for cooking should exceed 20 percent of the total number of households in the county.

2. Use of electricity for illumination of homes and for recreational activities is not to be lower than 90 percent.

3. Use of electricity for airblowing machinery should not be lower than 50 percent of the electrical use for cooking.

B. Estimating and analyzing classification of loads

Before estimating, materials on historical statistics and the state of the electric power system of the power supply region and the model load and estimated annual load curve for each classification of consumer should be collected. With the above materials, calculations and analysis of load estimates can be carried out.

There are the following methods of calculating the estimated unit use of electricity.

1. Unit consumption method

The unit consumption method means the unit consumption of electricity to produce a certain product or the consumption of electricity of a unit benefit.

The following formula can be used to calculate the annual electricity use and the maximum load:

$$Q_n = Pq, \tag{1}$$

where: Q_n = amount of power used annually

P = volume of output (or value of output, scale)

q = unit of power consumption

and

$$R = \frac{Q_n}{t}, \tag{2}$$

where: R = maximum load

t = number of hours of annual use of maximum load

The unit electricity consumption in Formula 1 is related to the factors of performance of equipment using electricity, degree of automation, production shifts per day, and level of management and can be set by localities through model surveys on the basis of actual circumstances locally. We provide some statistical materials (see Tables 1 and 2) for reference.

Table 1. Household Use of Electricity

Household use of electricity	Capacity equipment (watts/household)	Monthly power use (kWh/household)
Electrically cooked food (family of 5)	1,000 - 2,500	60 - 110
Increase for each pig raised		10 - 20
Illumination and entertainment (TV, radio, etc.)	100 - 200	6 - 15
Electric fans	40 - 60	4 - 12
Electric blowers for cooking	20 - 30	1 - 3

Table 2. Unit Power Consumption

Name and type of product	Unit of computation	Unit consumption of electricity index (kWh)
1. Coal mines		
Vertical shaft	ton	12 - 22
Sloped shaft	ton	7 - 20
2. Metallurgy		
Electrolytic lead	ton	160 - 240
Electrolytic aluminum	ton	18,000 - 20,000
Iron smelting	ton	8 - 10
Ferroalloys	ton	3,100 - 5,200
Carborundum smelting	ton	2,500
3. Metal working		
Automotive repair	vehicle	500
Agricultural implements	ton	235
Electric motors	kilowatt	3 - 8
4. Chemical industry		
Synthetic ammonia from coal tar	ton	2,500
Calcium magnesium phosphate	ton	1,000
Calcium superphosphate	ton	2,600
Calcium carbide	ton	3,150
5. Building materials		
Limestone cement	ton	105
Slag cement	ton	70
Machine-made brick	thousand	30 - 60
Lime	ton	16 - 20
6. Agricultural production		
Husked paddy rice	10,000 catties	35 - 45
Husked wheat	10,000 catties	40 - 50
Husked corn	10,000 catties	10 - 15
Dried (crops)	10,000 catties	33 - 500

[continued]

Table 2. [continued]

7. Agricultural sideline product processing		
Sweetened wheat powder	ton	50 - 70
Sweetened corn powder	ton	25 - 28
Milled rice	ton	15 - 25
Sweet potato powder	ton	3
Sliced root tubers	ton	2.4
Chopped green silage	ton	1 - 1.5
Chopped hay	ton	4 - 8
Crushed bean cake	ton	8
Other crushed silage	ton	10 - 20
Pressed bean oil	ton	350
Pressed peanut oil	ton	270
Pressed rapeseed oil	ton	135 - 250
Pressed cottonseed oil	ton	295 - 400
Electrically warmed sprouting	mu	3 - 4
Making sugar	ton	15 - 30
Making tea	ton	200
Ginned cotton	ton	20 - 23
Fluffed cotton	ton	50 - 70

2. Comprehensive need coefficient method

The ratio of the maximum load and the equipment capacity is the comprehensive need coefficient. Its value is related to the load character, scale of equipment, and overall facility and under ordinary conditions a country's comprehensive need coefficient is 0.2-0.3.

Quantity of electricity used per year can be calculated according to Formula (1) and the largest load may be calculated using the following formula:

$$R = KQ_h, \qquad (3)$$

where: K = customer comprehensive need coefficient

Q_h = total of capacities of equipment using power

To facilitate calculations some index data is here provided (see Table 3) for reference.

Table 3. Agriculturally Used Comprehensive Need Coefficient and Hours of Maximum Load Use Annually

Item	Hours of maximum load use annually	Comprehensive need coefficient	
		Scale of one transformer	Countywide
County-run industry	1,500 - 4,500	0.6 - 0.8	0.4 - 0.7
Commune and brigade enterprises	1,000 - 2,500	0.5 - 0.7	0.3 - 0.5
Electrically powered irrigation	750 - 1,000	0.6 - 0.75	0.5 - 0.6
Agricultural machinery repair	1,500 - 2,500	0.5 - 0.8	0.3 - 0.5
Agricultural sideline production	1,200 - 1,800	0.4 - 0.7	0.3 - 0.6
Grain treshing	300 - 500	0.65 - 0.7	0.5 - 0.7
Domestic illumination and entertainment	1,500 - 2,000	0.5 - 0.8	0.3 - 0.6
Electrically cooked food (more than 10,000 households) less than 2 appliances per household	120 - 180	0.35 - 0.45	0.28 - 0.35
More than two electric heating appliances per household	120 - 180	0.25 - 0.35	0.18 - 0.3
Electric cooling fans	500 - 1,000	0.6 - 0.85	0.5 - 0.6
Electric blowers for cooking	1,500 - 2,000	0.3 - 0.45	0.2 - 0.3
Other uses of electricity	1,500 - 3,000	0.6 - 0.8	0.5 - 0.7

3. Average rate of increase method

This method is suited to long-range calculations as in the formula below:

$$Q_n = Q_j (1+E)^n, \tag{4}$$

where: Q_n = amount of power not used after n years

Q_j = base amount of power

E = annual rate of increase

n = number of years in calculation

The above three methods have their strengths and weaknesses and thus, when carrying out the calculations there may be differences by region. However, when making specific calculations, it is best to focus on one method and then use the others for comparison. In this way the accuracy and level of the results of the calculations can be improved.

C. Drawing and analyzing the typical load curve of consumers by classifications

The load curve of an electric power system is a special curve which reflects the changes over time in the overall load of power customers within the system

and at the same time also reflects the process of change in the overall output of the power stations in the system. Thus, the reliability of the load curve will directly influence the rationality of selecting power station and transformer projects and the distribution of networks. To utilize water power resources effectively and fully develop the economic benefits of hydropower stations it is necessary to improve the precision of the load curve as much as possible.

1. Classification of load curve

(1) The load curve of representative days in the month with the highest load and the month with the lowest load (the load curve of winter and summer days) in a power system.

(2) The load curve of the annual highest month in a power system.

(3) The load curve by month of the average year in a power system.

(4) Representative load curves under other circumstances.

Of the above described classifications of load curves the drawing of the daily load curve in particular is most important. This is not only because it is the basis for drawing other load curves, but also because it is important material which reflects the load charactersitics of a power system.

2. Methods of drawing the daily load curve

Of the several ways of drawing [this curve] the most commonly used are historical curve revision method and the diejia [6613 0502] method.

The historical curve revision method uses the present actual typical daily load curve and the future load curve to make comparisons of the indicators and situations, and if the situations are comparable they use the former as the typical daily load curve; if there are changes, then the changed part is used to make revisions.

The diejia method is formed by carrying out a diejia on the typical load curve (representative winter and summer days) of various customers derived through survey and analysis on the basis of the planned anticipated load during the same period.

While drawing the daily load curve, counties can choose the specific drawing method on the basis of the characteristics of the county.

3. Amount of power accumulation curve

In the amount of power balance, the amount of power curve is a supplementary curve which determines the power station work position (primarily the position of the regulatory power station) in the power system and is also a curve which expresses the relationship of the load and the amount of power in the daily load chart. The steps in drawing the curve are:

(1) Arrange the load in terms of sustained time, then figure out the load difference of different sustained periods and the corresponding amount of power, then aggregate them.

(2) Using the load as the ordinate and the amount of power accumulation as the abscissa draw the curve on the basis of the points.

4. Annual load curve

The annual load curve consists of the annual greatest load curve and the annual average load curve. Under ordinary circumstances, the highest monthly load of the annual greatest load curve is derived by drawing a line connecting the highest load of the winter and summer. However, when specifically formulating plans, because there is the large seasonal load, therefore we propose using the following method for charting and drawing the curve.

First of all, take the load divisions in which peak periods are organized, such as nonseasonal load, seasonal load, largest load total, calculating in volume of line losses and expanded use of electricity; then according to the sequence of months from 1 to 12 record the above values according to month.

The average annual load curve can be drawn on the basis of the annual largest load curve. The specific method is: first arrange by item the largest load, the daily load rate, the average load of the day with the largest load (equal to the product of the largest load and the daily load rate), the number of hours for each month, the monthly use of electricity calculated on the basis of the largest load day (the product of the average load of the largest load day and the number of hours for each month), the coefficient (the ratio of the estimated annual gross electricity need and the electricity used monthly calculated according to the largest load day), the monthly average load (the product of the average load of the largest load day and the coefficient); then record the above values by month according to the sequence of months 1-12, and finally make a chart and draw the curve.

5. Drawing a distribution map of load countywide

First of all, calculate the overall largest load of regional electricity supply, mark on a countywide line connection map customers whose electricity use exceeds 180,000 volts, then mark with triangles load densities by unit area in accordance with the direction of flow, in this way the distributional system of rural loads can be graphically demonstrated. This map can also be used as basic material for researching electric network distribution and electricity supply proposals.

III. Power Source Planning

When planning electricity sources, first place the total generating output of existing power stations in 1982 for low water years (by month) on the 1987 load curve, recalculate the surplus and shortage in the amount of power, tentatively compute the gross capacity of the generating equipment that should be added, and balance it with the existing electricity sources. Then, on the

basis of the water power resources in the county and the characteristics of the river basin planning electricity source distribution, summarize the estimated load distribution situation for 1987 and choose a variety of power source points for technological and economic comparison. Finally, according to the recommended power source distribution points proposals, and the hydropower stations built or under construction in 1982, further balance the amount of power.

A. General principles of amount of power balance

1. Balance of amount of power can make the countywide power system rate of guarantee the highest and the operation the most economical.

2. In the process of balancing, first of all the output and amount of power of hydropower stations already constructed and under construction should be fully utilized; next, the amount of water of power stations in the system and the compensatory benefits of reservoirs should be fully developed to improve the guaranteed output and amount of power of the entire system.

3. When ladders are developed, if the highest level hydropower station has an annual (seasonal) regulatory reservoir and the hydropower stations below it do not have regulation or can only regulate daily, the entire ladder can be viewed as a hydropower station for purposes of compensatory regulation of the power system; if the hydropower stations at all levels have annual (seasonal) regulatory capability, then the best means for storing and releasing amount of water of all hydropower stations should be researched.

4. With regard to comprehensively utilized hydropower stations, attention should be paid to means of rational arrangement to avoid contradictions between them and other sections which use water.

5. Conscientiously analyze the hydropower station construction sites and the economic irrationality of the power supply region, to avoid creating irrational phenomena of power and amount of power trends.

6. When amount of power balance shows an excess, as much as possible arrange and develop high water and low water load customers in order to achieve a balance in loads.

7. On the basis of the characteristics of various power stations in power systems, it is necessary to pay attention to rationally allocating reserve capacity; moreover, to the extent possible utilize the power system's idle capacity for repair of generators so that the rated capacity of the hydropower stations will be as little as possible.

B. Determining various kinds of reserve capacity

1. Load reserve capacity

Load reserve capacity is considered 3-5 percent of the largest load of the power system of an entire county. Power stations which have the responsibility for load reserve are often called modulating power stations and their

rated capacity should not be less than 15 percent of the greatest load of the modulation region or the power system; moreover, generators which are operating should be able to rapidly accept or lose load at any time.

2. Emergency reserve capacity

Heretofore, in small-scale hydropower networks there has not been any emergency reserve capacity; however, in plans to electrify counties, the county power system capacity will reach 40,000-50,000 kilowatts and thus the proposal to build an emergency reserve capacity of more than 5 percent will guarantee the normal operation of the power system.

3. Overhauling reserve capacity

Determine the power balance according to the dry years of the power system design. For small-scale hydropower networks an overhaul reserve capacity may not necessarily be specially designed, however, in seasons when the system's greatest load declines and the annual planned overhaul for all generators cannot be realized, it is necessary to set up an overhaul reserve capacity.

C. Methods of amount of power balance

1. Accumulate all the power generated by natural flow during the same period by all hydropower stations participating in the operation of a power system and draw a curve of the rate of compensatory period, noncompensatory period and year-round gross capacity guarantee. In addition to this, view hydropower stations as one hydropower station and select one representative year for the entire system (making the selection on the basis of the rate of guarantees of 10, 50 and 90 percent for representative abundant, average, and dry years for the entire system). The system guarantee rate should be higher than the designed guarantee rate of the power stations.

2. Divide all hydropower stations into compensatory hydropower stations and compensated hydropower stations, then calculate the compensatory regulation (at the time of calculation the demands of the comprehensive utilization of hydropower stations should be taken into account). Through calculating the compensatory regulation of the entire power system, derive a process line of the average monthly output for hydropower stations in a representative hydrologic year.

3. Then place the pooled data of the process line of average output of hydropower stations so derived on the amount of power balance of the annual average load curve.

4. After amount of power balance, the balance of the process line of the average output of hydropower stations may be influenced; at this time, it is necessary through readjustment of proposals to bring the imbalance into balance.

5. On the basis of the monthly output derived through amount of power balance (taking into consideration the monthly regulatory coefficiency) use the daily load amount of power accumulation curve to balance the daily load.

6. Place the results of the daily load balance for the months on the chart of the annual largest load, and derive the power balance of hydropower stations by month. Then, after taking into consideration the accidental reserve capacity, the load reserve capacity and the overhaul planning, derive the capacity balance of the entire power system.

7. On the basis of the results of the amount of power balance, select a power source project and a yearly investment sequence.

8. Gather general statistics on power sources and customers outside the power system and finally derive an electrification index for the entire county.

IV. Power Network Planning

A. Several principles of power network planning

1. Prior to planning a new network, first technological reform should be carried out on existing power networks, level of operation should be improved, and rational transition should gradually be realized with regard to long-range goals in order to facilitate achieving the goal of economizing on investment.

2. On the basis of the situation in current rural power development, voltage levels should be combinations of 110 kilovolts/35 kilovolts/10 kilovolts. Within a county, between 60 and 35 kilovolts and between 10 and 6 kilovolts, one which is appropriate should be selected. However, priority should be given to choosing 10 kilovolts in the 6 to 10 kilovolt range. When determining the voltage level of a power system, the general principles of the relationship of transporting capacity, transporting distance, and voltage can be primary (see Table 4), then use the load distance method for comparison (see Table 5); and finally use the technological and economic comparison method for making the determination.

Table 4. Transmission Capacity and Distance by Voltage

Voltage (kilovolts)	Transmission capacity (10,000 kW)	Transmission distance (km)
10	20 - 200	20 - 6
35	200 - 1,000	50 - 20
110	1,000 - 5,000	150 - 50

Table 5. 10-35 Kilovolt Pylon Line Load Gap at a 10 Percent Voltage Reduction

Type of line / cosϕ / Wire type	10 kv line (kW/km)				35 kv line (megawatt/km)			
	0.95	0.9	0.8	0.7	0.95	0.9	0.8	0.7
LGJ-16	4,780	4,640	4,380	4,240				
LGJ-25	7,140	6,840	6,400	6,020				
LGJ-35	9,600	9,160	8,400	7,760	117	110	99	91
LGJ-50	13,300	12,300	11,100	10,000	160	147	129	116
LGJ-70	17,500	16,100	14,000	12,500	209	190	162	141
LGJ-95	22,600	20,200	17,100	14,800	265	234	194	166
LGJ-120	26,300	23,200	19,200	16,400	306	266	216	182
LGJ-150					362	308	244	202
LGJ-185					415	346	269	219

3. The distribution of rural substations is an important part of the plan. Preliminary distribution can be done on the planning area load map, then on the basis of the average load density of the districts in which the substations are located, calculate the permissible supply radius of a 35-kilovolt circuit (see Table 6), the economic power transmission radius for the corresponding 10-kilovolt line (see Table 7), and the capacity of the 35-kilovolt substations. Finally, check the results of calculations and the distribution of substations and if power demands cannot be satisfied, increased distribution may be considered until the actual use of electricity is satisfied.

Table 6. 35 KV Line Power Supply Radius at Different Power Coefficients

Transmission power rate (megawatts		2.0	3.0	5.0	7.0	9.0	10.0	12.0
Permitted supply	cosϕ = 0.9	49.8	46.1	40.0	35.4	31.8	30.2	27.5
Power radius	cosϕ = 0.8	52.6	46.6	38.0	32.0	27.7	25.9	23.0
(km)	cosϕ = 0.7	52.6	44.9	34.7	28.3	23.9	22.2	19.4

Table 7. Economic Power Supply Radius for Rural 10 KV Line

Load density (kW/km)	Supply radius (km)
Below 5	25 - 15
5 - 10	20 - 12
10 - 20	16 - 10
20 - 30	12 - 8
30 - 45	10 - 7
Above 45	<7

It is appropriate for the largest capacity for 35-kilovolt rural substations not to exceed 10,000-12,000 kilovolt-amperes, and the minimum not to be lower than 1,000 kilovolt-amperes. Two primary transformers of identical capacity should be chosen for substations but when the gap between peaks and valleys is large, one should be selected as major and one as minor, but the capacity of the minor should not be any lower than 2.5 times the lowest load.

4. Selection of capacity of distribution transformers should satisfy the demands that the lowest electricity use load be not less than 30 percent of the rated output of the transformer, the perennial load be within the range of 40-70 percent of the rated output of the transformer, and the rated output of the transformer not be smaller than the greatest load which actually could appear.

5. Since the density of the rural load is small, the customers scattered, and the transmission distances long, in planning, rational selection of wire plays an important role in insuring the quality of electricity supplied, lowering the investment in power networks, and economizing on materials. Calculating the load which is used in selecting wire should satisfy the needs of 5-10 years of development. For wire selection, it need not be done according to the economic current density, and will be acceptable as long as it permits lowering of the voltage (to less than 10 percent) as a controlling condition.

B. Method of planning power networks

1. Rationally divide up the power supply region and chart the loads separately on the basis of the power supply region's load density in the base year, the location and load characteristics of large customer load points.

2. On the basis of the amount of power trend distribution of the planning base year and the factors of network shipment, transforming, and distribution power, derive a power supply capability balance.

3. The power sources of small-scale hydropower networks are characterized by distribution in power supply regions, therefore, when making rough calculations of power and amount of power trends, the subregion load distribution map and the regional power source point's amount of power generated (and the power situation) should be used and balanced over the four seasons. In this way the amount of power for bringing in and sending out for the regions can be calculated.

4. For problems which appear in balancing the power supply capacity, draft several network plans and through repeated economic and technological demonstration and comparison finally decide on the best proposal for power network planning for the entire county.

V. Economic analysis and benefit analysis

A. Economic analysis

Economic analysis of small-scale hydropower projects includes two aspects, viz., economic calculations and financial calculations. Economic calculations are generally used in proving the proposal and selecting parameters; financial calculations are used to clarify the practical financial possibilities of building a hydropower station. It should be comparable with economic planning calculations, such as project results being comparable in quantity and quality, being comparable in national value of economic output and social expenses and prices.

In addition to this, when doing economic analysis, supplementary comparison indicators may be adopted (such as material or monetary indicators of calculating unit kilowatts or unit electricity).

B. Analysis of direct results

1. Basic economic indicators

Basic economic indicators are mainly project investment, number of hours of annual utilization of generating equipment, annual operation expenses (direct expenses and indirect operating expenses), and the generating costs of hydropower stations.

2. Methods of technological and economic comparison

(1) Compensation life method

$$T = \frac{K_1 - K_2}{C_2 - C_1} = \frac{\Delta K}{\Delta C}, \tag{5}$$

where: T = compensated years

ΔK = difference between investment of proposal 1 (K_1) and investment of proposal 2 (K_2)

ΔC = difference between annual operating expenses of proposal 2 (C_2) and annual operating expenses of proposal 1 (C_1)

In designing small-scale hydropower, the value of T is generally 10 years. If the results of the calculation are greater than 10 years, then a proposal for smaller investment and higher annual operating expenses should be selected; if less than 10 years, then a proposal for larger investment and lower annual operating expenses should be selected.

(2) Smallest gross expenditure method

$$S = \rho K + C, \tag{6}$$

where: S = minimum gross outlay

ρ = coefficient of standard result (taken as 0.1)

K = gross investment

C = annual operating expenses

3. Benefits analysis

We suggest using the dynamic method which has been widely used internationally in recent years. The methods of calculation of the dynamic method most often used are the following:

(1) Net benefit method:

$$B_j = B_m - (C+K), \tag{7}$$

where: B_j = net earnings

B_m = annual benefit

K = investment

C = annual operating expenses

When the value of B_j is positive, the proposal is the best one.

(2) Income cost comparision method

Income cost comparison is comparison of the current value of income with the present value of costs and when the value of the income cost comparison is greater than 1, that proposal is the better.

$$\frac{B_m \dfrac{(1+i_0)^n-1}{i_0(1+i_0)^n}}{K+C\dfrac{(1+i_0)^n-1}{i_0(1+i_0)^n}} \geqslant 1, \tag{8}$$

where: i_o = annual interest rate (percent)

n = number of years of project use

other symbols same as above.

(3) Internal recovery rate method

The discount rate i when present value of gross income and present value of overall costs are equal is the internal recovery rate and the higher its value then the better the proposal is considered. When calculating, the trial and error method may be used to derive the discount rate i of equality of present

value of gross income and present value of overall costs, and then be compared with the annual interest rate i_0 of the source of funds (such as a bank loan) and if i is greater than i_0, then the proposal is feasible but the greater the value of i, the better the proposal is felt to be.

(4) Investment recovery period method

The investment recovery period T is calculated according to the following formula:

$$T=\frac{\lg(B_m-C)-\lg[B_m-C-i_0(1+i_0)^n]}{\lg(1+i_0)}, \tag{9}$$

Symbols same as above.

The investment recovery period calculated using formula (9) generally is best if it does not exceed 10-12 years (in places where waterpower resources are lacking, 12-15 years may be accepted).

C. Analysis of social benefits

As the leadership comrades of the Central Committee have pointed out, developing small scale hydropower is a strategic measure for resolving rural energy, constructing a rural material and spiritual culture, and protecting forests. Therefore, the economic value of small-scale hydropower is not only in the sale of electricity, but more importantly has an inestimable role benefitting socioeconomic development, such as promoting local industrial development, promoting rural electrification, promoting bringing farmland under irrigation, and increasing local and commune and brigade capital accumulation.

For this reason, we should definitely do a good job of planning the basic county level rural electrification through small-scale hydropower.

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PRACTICAL OPINIONS OFFERED ON ACCELERATING RURAL SMALL-SCALE HYDROPOWER

Beijing SHUILI SHUIDIAN JISHU [WATER RESOURCES AND HYDROPOWER ENGINEERING] in Chinese No 6, 20 Jun 83 pp 59-61

[Article by Yu Kaiquan [0060 7030 3123], Institute of Scientific and Technical Information, Ministry of Water Resources and Electric Power: "Some Opinions on Accelerating Development of Small-Scale Hydropower in Rural China"]

[Text] Mankind has a 140-year history of using water to generate electricity. In the beginning it was small-scale, but later it gradually became medium-scale; by the 1940's there were single generators capable of producing 100,000 kilowatts, and by the late 1970's large-scale generators capable of producing 700,000 kilowatts had been developed. Some industrially developed countries also developed mainly small-scale hydropower earliest historically, but over a long period gradually developed medium-scale, large-scale right up to today's gigantic hydropower stations. Because the generating capacity of small-scale hydropower stations is small, it is not suited to transmission to remote locations, therefore these nations do not place as high an economic value on small-scale hydropower as they do on large- and medium-scale hydropower stations. However, the development and growth of the energy crisis, has affected more severely in particular those countries which rely on imports of cheap petroleum to generate electricity. This has forced those nations which rely on fuel oil to begin again to give serious consideration to the development of water power resources, to rebuild and expand existing hydropower stations, and to begin to investigate and search for other new forms of energy and to formulate policies for long-range, stable energy supplies. Because for small-scale hydropower stations the planning, design, and approval are simple, planning and preparation funding is easy, and construction time is short, in the past 5 or 6 years, the development of medium- and small-scale hydropower has attracted the renewed attention of the United States, Japan, and some Western European countries. For regions and countries in which agriculture is primary, developing rural small-scale hydropower stations has practical significance for bringing electricity to agriculture, improving production efficiency and the standard of living of the peasants, and reducing the gap between the city and the countryside.

China's hydraulic resources rank first in the world, but calculated per capita, the rated hydropower capacity per capita which is exploitable is still below the world mean of .54 kilowatts per capita. In this regard, accelerating development of China's water power resources and expanding the development of small-scale hydropower in the rural areas has evern greater strategic significance.

Given China's actual circumstances, the following views are presented on the development of small-scale hydropower:

I. Technical Problems in China's Small-Scale Hydropower Stations

A. Accumulation of hydrological records and data

For a great many of the numerous medium and small rivers in China, the hydrological records and collections of long-term hydrological data necessary for developing small-scale hydropower are lacking. At present, to construct a great number of small-scale hydropower stations immediately, it is often necessary to rely on short-term observations and measurements or hydrological data which have been derived through calculations, and thus it is difficult for the true hydrological characteristics of a river to be reflected correctly.

B. Topographical and geological survey data

China has only general small-scale topographical maps, data in the geological area are also very few, and readymade topographical and geological materials which can be used for small river development are even harder to find. To resolve this problem, it will be necessary to carry out crash supplementary surveys before planning and design.

C. The design and technology of small-scale hydropower stations

At present, in small-scale hydropower station design, some of the industrially developed countries of the world are striving for simplification, standardization, seriation, automation, and prefabricated assembly, and the adoption of new style generators. In China there is still a certain gap in this area, such as the lack of unified standards, and the practice of just knocking things together. For this reason, it is necessary to reformulate standard designs, and do a good job of making sets of equipment and, on the basis of technological advances, renew standardized design and complete sets of equipment within a set period of time.

D. Rational rated capacity and plant construction of small-scale hydropower stations

Calculated on the basis of a capacity of 8 million kilowatts and an annual output of 16.3 billion kWh, the average number of hours per year China's small-scale hydropower stations are used is only 2,030 hours, which works out to just 84 days. Thus, the number of days per year of full operation are too few. In this writer's opinion, for some small-scale hydropower stations, the rated capacity is not in conformity with the water power resources, resulting in a "big horse pulling a small cart." Moreover, there is little difference when compared with large- and medium-sized hydropower plants, in terms of plant design and internal arrangements, which does not capitalize on the characteristics of small-scale hydropower stations. In the future, when developing great numbers of small-scale hydropower stations, we should not imitate this again.

II. Several Opinions and Ideas

A. Using modernized facilities to collect hydrological data

China's territory is vast and there are many medium and small rivers, and there are a great many lacunae in hydrological observations due to the fact that communication is inconvenient. As a result, local areas should try to adopt foreign modern telemetry equipment to measure rainfall, water level, and flow in order to collect complete hydrological data. This equipment consists of many outfitted observation points at remote sites in an area managed by a control station by means of UHF radio so that the unmanned observation points automatically record and report. The control station has a computer and magnetic tape to establish and maintain the record over a long period of time. In this way, not only can reliable hydrological data be supplied for future development of water resources, but it is also an indispensible modernized facility for prioritizing flood prevention and generating electricity. Concerned automation plants and research departments should be asked to research high-volume production and marketing of this kind of equipment.

B. Adopt remote sensing and geophysical exploration technology to accelerate survey and exploration of water resources

China adopted remote sensing technology in off-shore petroleum exploration and in a short time found a large area of oil under the sea bed. According to reports, Japan used remote sensing technology only about 6 months before determining the small-scale hydropower situation nationwide as well as the landforms and geological situation. We propose that the state take the responsibility for applying remote sensing technology in the exploration along China's rivers to complete collection of data on and mapping of the landforms, topography, and geology of China's rivers, including the small ones.

C. Technological reform of small-scale hydropower stations

The factors which had an impact on the development of small-scale hydropower stations in the past were mainly that their capacity was small and unit construction costs were high. To attack this problem we may consider adopting some reform methods and measures to lower construction costs.

1. Simplified hydraulic structures

Medium- and small-scale reservoirs are mostly of the low-head type, thus in the last few years, at the Baigou Power Station in Guangdong, China has adopted placement of bulb-type generators inside the dam. In addition, the characteristics of bulb-type generators underwater are also used abroad to take into account water spilling over the plant building and when there is a small spread in water level in upper and lower reaches in periods of flood to utilize the turbines for releasing water to reduce the amount of water flowing over the dam and other sluicing facilities. In addition, noncofferdam floating construction methods can be adopted for such low-head sluice dams, navigation locks, and plant buildings. This not only has the advantage

of lower construction costs, but construction time is also short. In construction medium- and small-scale power plants abroad, in addition to utilizing locally available materials to build the dam, prefabricated structures are also used. Japan is now researching an "L" shaped prefabricated dam, which has the advantage of using the weight of the water to stabilize the dam mechanically and correspondingly reduce the length of the base, depending on the foundation's load capacity. The amount of concrete required for a dam of this structure is only one-third of that for a reinforced concrete gravity dam or one-fifth for a dam made purely of concrete. This type is even better suited for use in small dams in mountainous areas and for dam sites in river valleys with trapezoidal section. In addition, China has already researched and tested directional blasting dam construction technology at Nanshui. This construction method is a method of building dams in mountain areas which is both economical and gets quick results as well as saving on construction and being fast.

For small-scale hydropower stations there are much simpler arrangements, such as reducing the capacity of the forebay and reducing the number of gates and using rubber dams which fill or discharge automatically. Protective devices for penstocks, such as pressure regulating valves, and other means are used to prevent damage to the penstocks from excessive water hammer pressure when the generators are at full load. In addition to this, either open or semi-enclosed plant buildings may be used and 25-ton truck cranes may be used for hoisting purposes. The above are recognized as well developed and successful and should be considered when gathering new small-scale hydropower station standard design drawings for reference.

2. Rationally equipping and simplifying electromechanical equipment

Equipping small-scale hydropower stations should be rational to avoid the problem of "a big horse pulling a small cart." In addition, the relationship between rated capacity and joining a power network is very great. Experience abroad is that some small-scale power stations get together to form a small system and then later join a large system. To reduce the active power consumed within a system, install electrical equipment of a definite capacity, and improve the level of simplification and automation of small-scale hydropower stations so as to improve their economical and safe operation.

D. Simplification of small-scale hydropower stations and higher quality

In lowering the unit kilowatt construction cost of small-scale hydropower stations and raise quality, a great deal of work has been done both at home and abroad and some practical problems have been resolved. The Japanese methods are:

1. Hydraulic turbines

Expensive materials such as stainless steel are not used. To the extent possible, fixed vane axial flow generators are used in low-head, small-scale hydropower stations with attention to the problem of instability of flow or excessively low efficiency during times of low load operation. Prefabricated

concrete shells (horizontal axial-flow type) are used with attention to not influencing efficiency and the section shape should be simplified as much as possible for on-the-spot cured concrete shells for low-head, high-flow turbines; guide-vane automatic shutoff (spring-loaded shutoff guide valve), unoiled bearings and new-type water lubricated bearings, and simplified governor are used. For small-scale generators especially, complete assemblies are used more, the turning wheel of the turbines are of molded vane welded structure which insures the cleanliness and smoothness of the vane surfaces and increases the resistance to damage due to corrosion and improves turbine efficiency.

2. Generators

In joining a power system, asynchronous generators are used. To insure the quality of system voltage, capacitors which can eliminate governors or asynchronous devices at the time of simplified network connection should be added. When using synchronous generators, the circuits are small and thus require that their power factor be increased since the moment of inertia of designed generators is fixed, so in long water diversion systems the problem that the rate of increase of rotational speed will exceed the permissible values of the equipment should be considered. For generator voltage, 6.3 kilovolts should be adopted in order to facilitate direct connections with electrical distribution lines and thus eliminate transformer substations to increase the voltage. Generators and turbines can use a single axle and thus save on bearings.

3. Control devices

Automatic synchronous devices can be eliminated and compulsory or semiautomatic synchronization be adopted. In asynchronous generators, automatic voltage regulators need not be installed. In fixed blade generators, governors can be eliminated and automatic control starting be done by sluice gates and rotational speed circuit breakers, and in network connection and when full load operation has been achieved, if an accident occurs, automatically closing the sluice gates stops the generator.

4. Other aspects

Use manual booms, hangers, or truck cranes to replace fixed bridge type or gate type cranes within the building; use horizontal generators for ease of installation and repair; use fully automatic or semiautomatic power stations which are controlled by a central control station and inspected in rotation, and create specialized maintenance teams to reduce operating and maintenance personnel.

E. Standardization of small-scale water turbine generator structures

Through technical and economic comparisons, standardizing structures is a necessary road for integration and coordinated production in major production process.

To standardize generators, first of all the problems of existing small-scale hydropower stations should be analyzed and evaluated from the standpoint of standardization and then according to the different types of generators or according to the characteristics of specialized plant production, alignment charts of standard generators be should be drawn, then at the time of choosing, the standard generators can be selected from the charts on the basis of output and head.

At present, abroad there are numerous examples of the use of computers for selection of turbines and designing structures. As long as the effective head and designated output are provided, the computer can select the model of the turbine's equivalency curve and from the range of standards determine the most suitable vane diameter, and type and use it to process and produce the blades.

F. Seriation of generator selection

Generator seriation is based on product production, use, and development trends, grading similar products by size according to fixed standards and forming series by varieties to facilitate selection.

Hydropower stations are designed on the basis of natural flow and topographical conditions so it is very hard to find any site which conforms completely to all the technical norms, but there are a great many sites which are close to the water power norms of the small-scale power station. To the extent possible, small-scale hydropower stations which are close to the norms should use generators which have unified standards and unified structural dimensions.

Although the highest efficiency of the main generator may suffer when using unified series, the design expenses and time and the manufacturing die expenses saved are still considerable. Thus, seen from the perspective of the entire country, using unified series is advantageous in terms of manufacturing costs and especially where a great number of generators are put into operation in China every year the necessity of implementing seriation is clear.

At present, all turbines abroad are classified by the diameter of the turning wheel, but generators are classified by the diameter of the stator blades. Where the effective head and the flow are slightly different but are still fairly close, a turning wheel of uniform diameter may be chosen on the basis of the equilibrium curve of the turbine as long as the loss of efficiency is not great. If a generator uses the same core diameter, a different core need not be used to adjust the output of the generator.

Where the effective head is different, but the flow is basically the same, a turning wheel of the same diameter may be used and the maximum output point may be determined depending on the rated rotation speed. If the vanes are fixed, as long as the vane angle is good, then the turbine can operate optimally. If the discrepancies between generator capacities are great, then different voltage levels can be used to change the output of the generator.

In addition to this, when the effective head is basically the same but the flow is different, while using the same model turbine and same design, this can be resolved by slightly shifting the highest efficiency position of each one.

8226
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SMALL-SCALE OPERATIONS BOOST OUTPUT TO 9.04 BILLION KWH BY MID-1983

Beijing RENMIN RIBAO in Chinese 5 Aug 83 p 2

[Article: "Small-Scale Hydropower Throughout Nation Increases Output in First Half of Year"]

[Excerpt] The Ministry of Water Resources and Electric Power has reported that by the first half of 1983, the output from small-scale hydropower operations throughout the nation had reached 9.04 billion kilowatt-hours, 2.2 billion kilowatt-hours more than the same period of 1982, or an increase of 33 percent. Some provinces, including Yunnan, Guizhou, Hebei, Shandong, and Jiangxi, increased their output by more than 50 percent.

The number of small-scale hydropower stations going into operation in the first half of 1983 was actually smaller than last year. The reason for the big jump in output (outside of the fact that the South had heavy rainfall) was that the various regions improved management, vigorously worked to complete the power grids, and made use of seasonal energy resources to increase economic benefits.

CSO: 4013/306

SMALL-SCALE OPERATIONS ACCOUNT FOR ONE-THIRD OF RURAL POWER CONSUMPTION

OW121813 Beijing XINHUA in English 1436 GMT 12 Oct 83

[Text] Beijing, 12 October (XINHUA)--The generating capacity of China's small hydroelectric power stations will increase by over 500,000 kilowatts this year, according to a national conference on small hydroelectric power stations which opened here today.

About 200,000 kilowatts went on stream in the first three quarters of this year and another 300,000 kilowatts are under construction and will go into operation before the end of the year.

Small hydroelectric power stations are those with single generating units not exceeding 6,000 kilowatts and group generating units not exceeding 12,000 kilowatts.

At present, China gives priority to hydroelectric power development. While big efforts are being made to build large-and medium-sized hydroelectric power stations, the country encourages all localities to build small ones to make electricity more widely available in rural areas.

In the first three quarters of this year, China's small hydroelectric power stations generated a total of 14.5 billion kilowatt-hours, 34 percent more than in the same period of last year.

There are now more than 80,000 small hydroelectric power stations, with a combined generating capacity of 8.28 million kilowatts. Guangdong, Fujina, Sichuan, Hunan and Zhejiang lead the country in construction of small hydropower stations.

About one-third of rural consumption of electricity comes from small hydroelectric power stations. Of China's more than 2,000 counties, 774 rely mainly on small hydroelectric power stations for power supply. The growth of small power stations will stimulate the development of the rural economy and help raise the peasants' living standards.

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